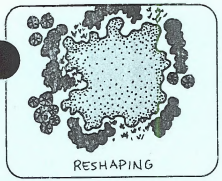

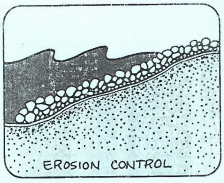

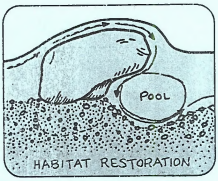

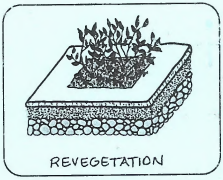

PLACER MINING IN ALASKA

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A Guide to Mitigation and Reclamation

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ALASKA STATE OFFICE
ANCHORAGE, ALASKA

First Edition
March 1987

TABLE OF CONTENTS

Preface

I. Introduction Page 6

II. General Considerations Page 8

III. Access to the Operation

A. Minimizing Impacts Page 12
B. Fish Passage and Culverts Page 13
C. Dealing with Ground Ice Page 14
D. Cuts in Permafrost Page 14
E. Appendix Page 18
1. Environmental Guidelines for Development Roads in the Subarctic (partial)

IV. The Operation

A. BLM Responsibilities Page 24
B. Planning for Surface Protection Page 24
C. The Disturbed Area Page 32
D. Buffers Page 34
E. Topsoil Page 34
F. Erosion Page 37
G. Fisheries Page 37
H. Toxic Materials Page 38
I. Site Drainage Page 38
J. Settling Ponds Page 45
K. Aufeis Page 53
L. Minimal Degradation Page 53
M. Appendix Page 54
1. BLM Riparian Area Management
2. Best Management Practices for Placer Mining-Reference Manual (partial)
3. Best Management Practices for Placer Mining-Technical Report (partial)
4. Placer Mining Wastewater Treatment Technology Project-Executive Summary

V. Ending the Operation (Reclamation)

A. General Considerations, Goals, and Equipment Page 77
B. Periods of Non-Operation Page 78
C. Fish and Wildlife Habitat Page 80
D. Streams and Floodplain Rehabilitation Page 80
E. Revegetation Guidelines Page 85
F. Site Preparation for Revegetation Page 87
G. Selecting Species for Revegetation Page 88
H. Seeds or Seedlings Page 89
I. Seed and Fertilizer Page 89
J. Post-Operations Monitoring Page 90
K. Appendix Page 91
1. Basic Outline for Rehabilitation of Mined Lands
2. A Revegetative Guide for Alaska
3. Field Guide for Streambank Revegetation

VI. Glossary Page 119

VII. Annotated Bibliography Page 138

VIII. Selected Bibliography Page 142

IX. Case Histories Page 160

March 18, 1987

To The Reader:

This document represents a composite and synthesis of contributions by a number of people, Bureau of Land Management (BLM) personnel as well as others. Principal contributions were made by personnel from the BLM, Alaska State Office, Branch of Renewable Resources and the Branch of Pipeline Monitoring.

Please direct comments, questions, etc., to:

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PREFACE

Bureau of Land Management (BLM) personnel concerned with surface protection in Alaska must be aware of the potential impacts of a surface disturbing activity, as well as techniques available to help mitigate these impacts. This guidebook is an effort towards providing field personnel with some of the technical information they may need to adequately manage BLM lands. It by no means represents the final word, or the only way to achieve compliance with the laws and regulations concerning surface protection, in pursuit of the ultimate goal of minimizing adverse effects upon the environment.

Information is presented in various ways, with a question/discussion format emphasized. Annotated and selected bibliographies as well as a glossary have been included. The references should be consulted for details of the various topics discussed in this sourcebook. These references are obtainable through standard library sources.

If you would like a copy of this document or would like to submit corrections or additions, please contact:

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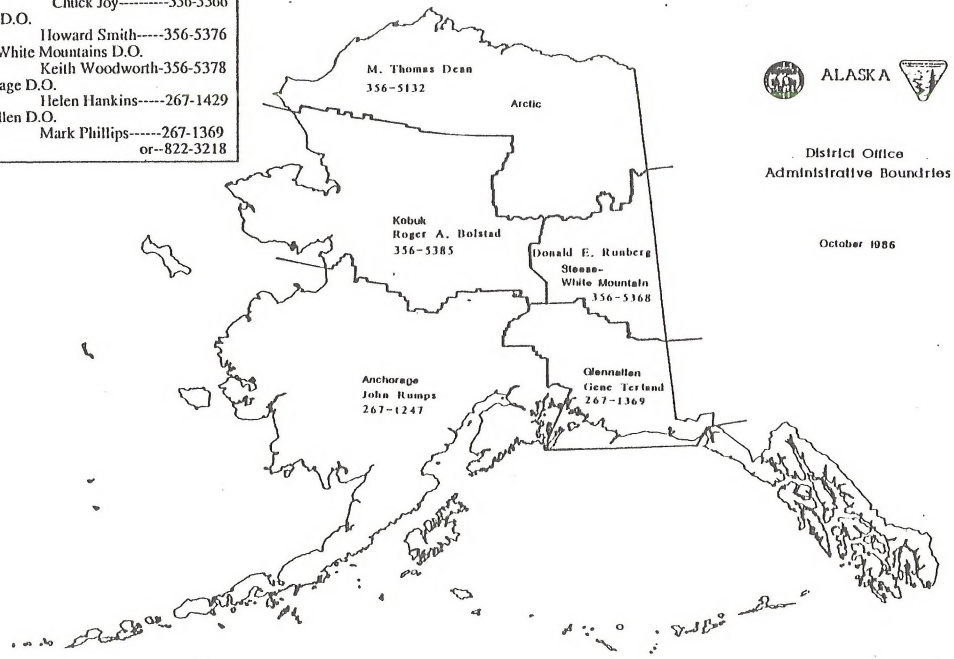


ALASKA

District Office
Administrative Boundries

October 1986

ACKNOWLEDGEMENTS

This is to express appreciation for the essential contributions of numerous people in support of the preparation of this guidebook.

In particular, Kelly Riley most capably and conscientiously typed and re-typed numerous versions, while ably keeping up with her many other responsibilities as well and often under severe time constraints. Her accuracy, timeliness, unfailing good spirits, and constructive attitude were noteworthy. Her ability and willingness to contribute even more, in terms of excellent language and organizational skills, merit additional commendation.

Linda Mowatt assisted most capably in the latter stages of document preparation and related correspondence, under severe time constraints. Her attention to detail, attitude of cooperative interest and concern, and excellent language skills were manifest in particular during her careful re-compilation and re-typing of several portions of the guidebook.

The patience and ability of both of the above individuals in deciphering oftentimes well-nigh illegible handwriting is recognized with sincere appreciation.

Preparation of a document such as this in any reasonable time-frame without excellent library support would have been impossible. The Alaska Resources Library, now part of BLM - Alaska, Division of Support Services, supplied this essential ingredient in exemplary fashion. Martha Shepard, Head Librarian, and the staff - Mary Ferber, Acquisition Librarian; Linda Tobiska, Inter-Library Loan Librarian; Ramona Mierjewski, Cataloging Librarian; Delores Hunter, Library Technician; and Mary Crosby, Library Assistant - represent all that any library could reasonably aspire to be. The excellent professional knowledge and skills continually manifest were most impressive, along with other aspects such as cooperative interest/concern, willingness to assist, and a most pleasant general personal atmosphere. They unfailingly have been able to unearth obscure references, provide timely and accurate service, and individually as well collectively, are to be most highly commended and gratefully thanked.

Wayne Boden, David Dorris, Richard Dworsky, Arlan Kohl, and Richard Vernimen are sincerely thanked for providing various combinations of conceptual input, physical and moral support, and a working atmosphere most conducive to productive professional effort.

NATURE OF GUIDEBOOK

This guidebook is intended for BLM personnel. It is not intended to be a law enforcement manual, but it is concerned with the requirements of 43 CFR 3809 because managing the surface disturbing effects of mining is a priority for BLM in Alaska. Under 43 CFR 3809, BLM has been directed to prevent unnecessary or undue degradation of Federal lands which may result from operations authorized by the mining laws, in a manner that will not unduly hinder such activities, while providing for mineral entry, exploration, location, operations, and reclamation of disturbed areas. In addition, the procedures BLM uses are to be coordinated, to the greatest extent possible, with appropriate State of Alaska statutes and procedures for prevention of unnecessary or undue degradation of the land and other resources.

This guidebook has been divided into discussions of access, operation, and reclamation, for clarity of presentation. Distinctions such as these are of course somewhat artificial, since these three categories are complexly inter-related in each particular situation involving surface disturbing activities. As well, various technical matters (e.g. stability, erosion control, revegetation, etc.) are equally of concern to each category of activity. This must be kept in mind, while using this guidebook. Relevant material of particular interest has been selected for incorporation - in part or completely - in an Appendix to each of these Chapters where this was appropriate.

There is an extensive and expanding literature in existence regarding various aspects of the general topic of "reclamation". Most of this is concerned with activities in more temperate climates, and hence, must be considered with due reservation in terms of applicability in Alaska. General physical and biological principles are common factors, but there are many unique aspects which must be taken into account for successful operations in Alaska.

The information presented here was developed from the literature, together with discussions with BLM field personnel and other interested parties. It is important to recognize that the reader must be selective and use good judgement in applying any information contained in this document to the activity at hand. In other words, not every idea in this document will be applicable to a particular situation. If a reference or diagram calls for using straw bales in some type of sediment control structure and none are readily available, don't disregard the entire concept; maybe spruce boughs or something else can be substituted. BLM regulations do not stipulate how compliance with a desired result is to be attained except to caution the user of the public domain against violating any other federal or state regulations while meeting BLM requirements. Materials included in the appendices to various Chapters, together with references listed in the bibliographies should be helpful in providing suggestions - ideas regarding the "how to do it" aspects of designs/methods which might be considered by an operator in

attempting to meet the required performance standards for any particular situation. BLM is not in a position to recommend design standards, except perhaps in a very general fashion in some instances, but, rather must manage surface-disturbing activities on public lands by means of performance standards.

It is essential to appreciate that any specific techniques, procedures, etc. presented, commented upon, or alluded to in this guidebook are not to be construed as representing anything more than suggestions - ideas - concepts of a somewhat general nature. They will rarely, if ever, represent the only means by which mitigation - reclamation goals may be achieved, in any given instance. Given the diversity of physical and biological activities and factors of concern in an area as extensive and varied in character as Alaska, flexibility in approach must be paramount. Our appreciation and understanding of the complexly interwoven relationships of the various natural settings of concern are by no means sufficiently thorough as to suggest that any other approach would be reasonable or proper. To varying degrees, each situation represents a somewhat unique composite set of circumstances, which demands, commensurately, a flexible, reasoned interaction in terms of operations and attendant mitigation - reclamation. Each situation must be clearly elucidated, on a "case-by-case" basis.

This guidebook is not intended as a "cookbook" or panacea. It is intended to address some general aspects of concern, and to point out existing information elsewhere to which interested parties may refer. The overall objective is to facilitate management of the effects of surface disturbing activities - otherwise of benefit to human society - so that attendant harmful impacts to various natural resources are minimized. In this context, it is imperative that the nature of the surface disturbing activity - mining, or other - be clearly understood, so that mitigation - reclamation will be effective as well as practical.

Use the information in this handbook to help formulate solutions, and if you come up with a good one, share it with others. This document is intended to be useful. If you know how to express something better, or if you know a better way, share it, and let us know.

II. GENERAL CONSIDERATIONS

BLM ROLE

The BLM has the dual role of both encouraging the use of and protecting the public domain in Alaska. For example, in some areas of sensitive fish and wildlife habitats, a professional land manager may feel that there is no acceptable level of surface disturbance and may recommend closure of the area to all surface disturbing activities. In other areas, such as long established mining areas, surface disturbance may be so extensive that a professional land manager may recommend allowing significant surface disturbances as the priority land use as long as new disturbed areas are reclaimed and effluent from the activity meets State and Federal standards.

The two examples in the preceding paragraph are basically the two opposite extremes of surface protection. However, most BLM management concerns deal with surface disturbing activities between these two extremes. In general, no BLM area is ever totally closed to all disturbance, nor is any area ever written off as unreclaimable no matter what the cost of reclamation might be.

WHEN DOES SURFACE DISTURBANCE BEGIN?/WHEN DOES RECLAMATION END?

Basically, the BLM person in the field determines when surface disturbance has occurred, and when reclamation has been achieved. It is the field person who can determine when "casual use" has been exceeded and when a user of the public domain has restored a "project area" to an acceptable condition. BLM field judgments are balanced by an appeal process to protect the rights of the user.

CONTROLLING DISTURBANCE, AND RECLAMATION: THE PIPELINE (TAPS) EXPERIENCE

(Adapted from Brown and Berg, 1980; Johnson, 1981)

Minimize Surface Disturbance:

1. Emphasis should be placed on minimizing clearing of vegetation and disturbance of surface materials.

2. Unless a permanent access road is to be built, all access should be conducted on frozen or snow covered surfaces. The use of vehicles that exert low ground bearing pressures should be required for any access not using permanent roads.

3. Excavated materials should be placed where they will not adversely disturb vegetation, the thermal regime or surface drainage.

Fish and Wildlife Disturbance:

1. Free passage and movement of terrestrial and aquatic organisms should be maintained.

2. Permanent alteration of stream hydraulics or disturbing significant areas of river or stream beds or vegetated banks should be avoided.

3. Erosion and sediment control structures should be used to the maximum extent possible during the thaw season to minimize impact on water quality.

4. All activities should be restricted in key fish and wildlife areas during periods of fish and wildlife breeding, nesting, spawning, lambing, calving activity, overwintering, and during major migrations of fish and wildlife. Such key areas should be clearly and throughly substantiated with regard to the spectrum of considerations inherent to multiple-resource management.

Drainage and Erosion Control:

1. Temporary erosion control was a recurring problem during construction, and remains a minor problem.

2. Access over stream banks should be made by filling rather than cutting whenever possible, to lessen erosional problems.

3. Riprap and armour stone should be of sufficient size to remain in place and be effective at peak discharges.

Cuts in Ice Rich Soils:

1. Cuts should be made with nearly vertical backslopes.

2. A wide ditch should be provided at the toe of the cut.

3. Trees and shrubs should be hand cleared from the top of the cut for a distance from the top edge of the cut back to approximately one and one-half times the height of the cut. Stumps should be cut as close to the organic mat as possible but should be left no taller than one foot in height. As thawing and subsidence occur during the stabilization process, it might be necessary to hand clear additional trees.

Reclamation:

1. Initial revegetation along TAPS was based primarily upon the accepted practices of mulching, fertilizing and seeding with adapted agronomic grass species. Attempts to use native grass species in the seed mix were limited. Native grasses are only slowly reinvading some artificially revegetated areas. The long-term persistence of exotic species from initial revegetation efforts and the effect upon reestablishment of native vegetation is still being studied. Native tree and shrub transplants and cuttings had limited success in relationship to cost.

Current practice stresses establishment of erosion stability, elimination of any ponding and encouraging native vegetation as quickly as possible.

2. Some pipeline restoration problems were irremediable, such as those involving the loss of topsoil and organics which were buried or otherwise lost during operations.

Current practice calls for segregation of slash, organics/topsoil and overburden into separate stockpiles at any excavation.

GENERAL CONCERNS

The principal considerations regarding management of surface disturbing activities on Public Lands in Alaska can be summarized, in a rather general fashion, somewhat as follows:

1. Saving of all available topsoil (including the organic mat) for final respreading after reshaping the disturbed areas.

2. Stabilization of the saved topsoil, overburden and disturbed areas to prevent erosion, landslides or degradation of adjacent waters.

3. Isolation, removal or control of toxic materials.

4. Provision for fish, wildlife, and human passage during and after operations; rehabilitation of habitat.

5. Revegetation of all disturbed lands to prevent erosion prior to final reclamation, and as an essential part of such final reclamation.

6. All slopes or river banks cut or filled during access or operations must be stabilized to prevent thermal, water and/or wind erosion.

7. A. As each part of an operation is completed, erosion control devices should be installed as required, and the area should be reshaped, sloped, and graded to blend with surrounding landscapes and to minimize ponding and/or erosion.

   B. Economic material handling generally entails minimizing the equipment and number of steps utilized in achieving the desired result. Ideally, removal, processing and placement of materials into the final reclaimed configuration and condition should be essentially one continuous function within the same operating season. One important advantage of this in Alaska is that the final emplacement of the materials is effected before freeze-up. During the winter piles of topsoil, overburden and tailings will freeze from the surface down; if placed over existing permafrost soils, the permafrost will facilitate freezing of the piles from below as well. This of course will present problems when these frozen stockpiles of materials

subsequently need to be moved for reclamation. The water-saturated fine-grain size (silt/clay) materials in settling ponds are highly susceptible to freezing – in some cases may permanently refreeze. Subsequent movement/modification of such materials would be difficult and expensive. It might be noted that there is a positive aspect to this latter situation, in that the fine-grained materials thus frozen are essentially "fixed" into a relatively much less erodable state, which feature might used to advantage in some situations.

The remainder of this guidebook will address the specifics of these general concerns.

III. ACCESS TO THE OPERATION MINIMIZING THE IMPACTS OF ACCESS

The access route is an integral part of an operation, and the operator is responsible for any unnecessary or undue degradation resulting from the construction, use or improper restoration of any access route. In Alaska, such access should:

a. Be constructed to the minimum BLM standards listed in BLM Manual Section 9113, or be designed by a licensed professional engineer.

b. Incorporate a design commensurate with use, and consistent with the need to maintain environmental integrity.

c. Avoid crossing active river and/or stream channels. If necessary, however, crossings should be made via temporary bridges, properly installed culverts or correctly constructed low-water crossings (LWC).

d. Use gravel fill ramps at stream bank crossings to minimize siltation, rather than cutting through the bank.

e. Avoid high erosion hazard areas; in some cases a slight location change may eliminate a major erosion problem.

f. Avoid access through vegetated areas but, if necessary:

1. Access across vegetation in the snow-free season should not be made with any vehicle that would remove or damage the organic layer, without a properly constructed permanent gravel road.

2. Winter access across vegetation should not be made until the organic layer is protected by an adequate layer of snow and ice or the organic layer has been protected by the construction of snow and/or ice roads capable of supporting vehicular traffic with minimal effect on the organic layer.

g. Be planned for the minimum width needed for operations and should follow natural contours, where practicable, to minimize cut and fill.

h. Have turnouts on single-lane roads that take advantage of natural existing sight distance and topography.

Lotspeich and Helmers (1974) discuss "Environmental Guidelines for Development Roads in the Subarctic" (see Appendix III). Other references are given in Chapter VIII.

PROVIDING FOR FISH PASSAGE/INSTALLING CULVERTS

(Adapted from USDOI-FWS, 1980a)

When encountering a stream or river on the access route, provision must be made for safe passage of equipment, water flow and fish. If the stream is shallow a simple non-degrading low-water crossing may be optimal. If the stream flow is more variable, a bridge would be preferable for fish passage, but may not be economically feasible, leaving construction of a culvert as the best option.

Culverts in Alaska are usually the corrugated-metal-pipe (CMP) variety, although effective and economical culverts can be constructed from timbers. Regardless of what type of culvert is chosen, there are certain guidelines which should be followed in any fish stream to provide the maximum opportunity for fish passage:

a) Log stringer or timber bridges and log/timber culverts are the most desirable fish passage structures because they maintain the natural stream bed and gradient.

b) Arch metal culverts with an open bottom are also preferable to round culverts because they retain natural bed materials. Closed arc culverts are second in preference.

c) Horizontal ellipse culverts can maintain natural bed material and stream flow width if the culvert invert is placed below the stream bed elevation.

d) In general, the average water velocity through a culvert should not exceed approximately three feet/second during fish migration periods. Many fish species require velocities considerably less than this during migration periods and fish passage can be impeded at velocities of only one foot/second.

e) A 3-day delay period for fish (3 days of velocities in excess of those required for fish passage) should not be exceeded during the mean annual flood (2.33-year recurrence interval flood). A 7-day delay period should not be exceeded in the design flood.

f) The culvert should be constructed so that the water level in the culvert is not less than 8 inches during the open-water season when fish passage is necessary.

g) Culvert inverts should be laid a minimum of 6 inches below normal stream bed elevation or have a burial depth of 20% of culvert diameter.

h) Culvert inverts should be designed and installed to prevent hydrostatic uplift at the downstream or upstream end.

i) Culvert gradient should be kept as close to the natural gradient as possible so that no upstream or downstream velocity barriers are created.

j) Culverts should have sufficient capacity to pass the design flood with no backwatering or ponding at the upstream end.

k) Culverts should not be placed where a channel cutoff or diversion would result.

l) Culverts should not be placed where the discharge is directed at an unstable bank.

DEALING WITH GROUND ICE IN CONSTRUCTING ROADS AND MINING

(Adapted from Brown and Berg, 1980)

Do everything possible to prevent unnecessary melting of ground ice when constructing roads and mining. Ground ice is associated with permafrost, and its abundance and distribution are significant considerations in route selection, road design, construction practices, maintenance requirements and operating methods. The majority of ground ice occurs in fine-grained, unconsolidated sediments. Ground ice can also occur as pore ice, ice films, lenses, layers, sheets, wedges and possibly buried glacial ice. If the access route or operation thaws ground ice, costly remedial measures may be required to restabilize the area.

HANDLING CUTS IN ICE RICH (PERMAFROST) SLOPES

(Adapted from Brown and Berg, 1980)

The proper way to achieve access across an ice rich slope is to fill rather than cut. However, if access routes or operations involve cuts in ice rich materials, the slopes may take years to stabilize, even if the following recommendations are followed:

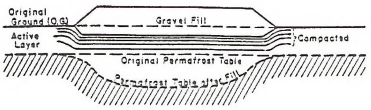
a) Cut nearly vertical backslopes on the cuts (in mining, if a cut is to be pushed no farther into the permafrost slope, it may be possible to grade spoil up against the vertical cut face as soon as possible following mining at that location, and modify items b, c, and d).

b) Provide a wide ditch at the base of the cut to allow removal of even more material as well as to allow deposition of melting ice rich material during the stabilization process. The ditch will also permit a porous revetment to be made to enhance drainage and stabilization of the slope.

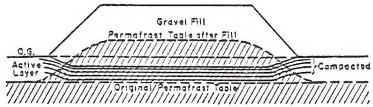
c) Hand clear trees and standing brush from the top of the slope for a distance about equal to one and one-half times the height of the cut. Stumps should be cut as close to the surface as possible and left no taller than one foot. All efforts should be made to keep from damaging or tearing the vegetative mat. As melting and subsidence occur during the stabilization process, it might be necessary to remove additional trees from the top of the slope.

d) Seeding, if required by the Authorized Officer (AO), should be attempted only on relatively stable portions of the slopes. Near the end of the first thaw season, the lower portion of the slope should be heavily seeded with grasses and fertilized to try to establish a relatively firm and stable toe down into the drainage ditch before thawing occurs the following season. If this procedure is followed for two or three successive seasons, grasses may slowly establish themselves from the toe of the slope up to the natural vegetative mat edge as subsidence progresses. If the slope is not seeded, natural invasion by seed or resprouting of root material is likely to occur within several summers as subsidence slows.

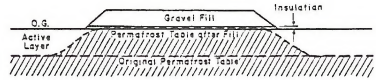
FIGURE 1 . Effect of gravel fill and insulating layers upon thermal regime (Brown and Berg, 1980).



a. Effect on permafrost table if insulating effect of fill plus compacted active layer is less than the insulating effects of original active layer

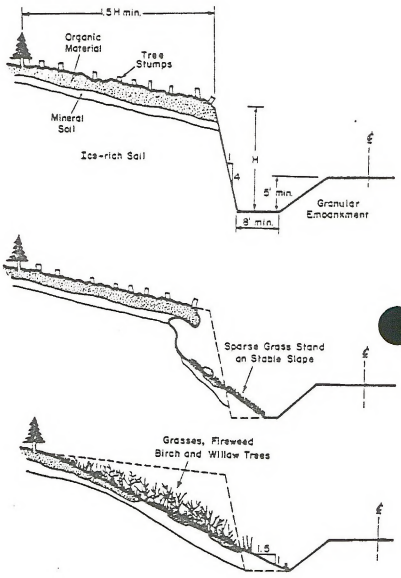


b. Effect on permafrost table if insulating effect of fill and active layer is greater than the insulating effect of the original active layer



c. Effect on permafrost table if insulating effect of fill, insulation and active layer is greater than the insulating effect of the original active layer

FIGURE 2 . Idealized development of stability in ice-rich cut (Brown and Berg, 1980).



a. Initial frozen cut profile.

b. End of first thaw season. Slope is mostly unstable and very unsightly; ditch will require cleaning if massive ice is present.

c. End of fifth or sixth thaw season. Slope stabilizes with reduced thaw and vegetation established. Free water from minimal thawing is used by plants whose root systems develop new organic material.

APPENDIX III

ACCESS TO THE OPERATION

Included in this Appendix is a copy of a portion of a publication which may be particularly useful in providing concepts/techniques, etc. relevant to access to operations. Additional information can be obtained from other references listed in Chapter VIII.

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June 1974

ENVIRONMENTAL GUIDELINES

FOR

DEVELOPMENT ROADS IN THE SUBARCTIC

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ABSTRACT

This set of guidelines is based on Federal and State regulations that set standards to protect the total environment. Although major highway construction is under stringent regulation, pioneer type access roads such as are needed by loggers, miners, land developers, etc. have been neglected. These smaller roads frequently pose serious erosion hazards because planning, design, and construction of them is not thorough, as it is for major roads; this results in erosion, fire and insect traps, and generally unattractive roadways.

Suggestions and recommendations contained in these guidelines are for the use of operators with limited engineering and planning staffs. Although all examples of poor practices are from the vicinity of Fairbanks, all suggested treatments are taken from the literature from the conterminous United States, with some modifications for subarctic conditions. Most of these recommendations are simple in concept, and if properly applied, do prevent erosion and result in superior access roads which are esthetically pleasing.

CONTENTS

	Page
Abstract	ii
List of Figures	v
Acknowledgments	vii
Preface	viii
Conclusions	1
Introduction	2
Objectives	2
Scope	2
The Substrate	3
Recent Federal Legislation	3
Planning and Route Selection	7
Road Design	12
Road Prism and Gradient	12
Spur Roads	20
Drainage	20
Erosion Control	27
Construction	35
Surveying and Right-of-Way Clearing	35
Earthwork	40
Support Activities	42
Restoration	43
Road Maintenance	46
Putting Roads to Bed	49
Guidelines for Putting Roads to Bed	49

	Page
Roads on Muskegs	52
Introduction	52
Muskeg Properties	52
Road Construction	52
Ice Bridges	55
References	60

IV. THE OPERATION

BLM RESPONSIBILITIES DURING OPERATIONS ON PUBLIC LANDS

Under surface protection regulations, BLM has responsibilities during the approval and operational phases of an activity on the public lands, as well as for insuring adequate reclamation. As indicated in the preceding section on accessing the site, proper planning can eliminate or minimize impacts upon the surface resources.

PLANNING FOR SURFACE PROTECTION

Planning for surface protection need not be elaborate, but it does need to be done carefully.

It should be stressed that BLM neither recommends nor provides design criteria or standards, but, rather, manages surface-disturbing activities via use of performance standards. In other words, BLM will attempt to define acceptable levels of performance, in terms of existing legal requirements together with site-specific judgments, but is not in a position to direct the operator in the specifics of attaining such acceptable performance. Reference to the attached annotated bibliography and selected bibliography (Chapters VII and VIII) will reveal various publications which address the technical aspects of relevant topics in detail.

Several factors should be considered by the operator and BLM when planning the surface disturbing operation:

a. Technical Aspects, such as the:

   1. Extent of the proposed disturbance.

   2. Extent of processing, mobile and stationary equipment, and operating skills required.

b. Economics, such as:

   1. How far and how easy is it to get there with the proper equipment?

   2. How much site preparation, including overburden removal and construction of ancillary structures (cabins, access roads, airstrips, etc.) is required?

   3. What type of stream diversion or training structures are required?

   4. What is the cost of rehabilitation?

c. Environmental characteristics, such as:

   1. Can effluent and other environmental requirements be met?

The BLM must be especially concerned with gathering enough baseline data on each operation to meet NEPA documentation requirements and to allow advising the District Manager on the appropriate course of action . In support of this data collection, the field BLM person should call upon other BLM expertise, i.e. sociologist, archaeologist, engineer, geologist, hydrologist, soil scientist, vegetation specialist and fish and wildlife biologist for timely input and advice. This expertise could be in the districts or state office.

A thorough plan should:

a. Locate all streams and ponds, existing settling ponds, existing tailing piles and aufeis fields.

b. Identify the operational location or locations with respect to floodplain location type, such as active channel, active floodplain, highwater channel, inactive floodplain, abandoned channel, terrace or valley wall.

c. Have a map showing the size and relative location of all work areas on the site.

d. Describe the season, duration and frequency of all site work by individual work area, that is - approximate dates the entire and portions of the operation will begin and end.

e. Describe and locate all buffer (undisturbed land) strips and give dimensions and vegetation type.

f. Describe the methods, schedules and locations for vegetation and overburden clearing as well as handling and storage of topsoil.

g. Describe the operational methods. Include descriptions of the type of equipment to be used and descriptions of the intended processing steps such as lifting, sorting, sluicing, placing tailings, spreading tailings and topsoil, etc.

h. Give an estimated cross-sectional configuration of the mine site, at various working portions of the site.

i. Give specific locations, specification, material composition and construction method for access roads, river diversion and/or training structures and sediment control ponds.

j. Describe all logistical support and material transportation methods, general routes to be followed and season/frequency of movement of equipment and supplies to and from the site.

Figures 3 through 7 illustrate various common types of terrain features, and relevant terminology.

FIGURE 3 . Schematic diagram of the plan view and two cross sections of a typical meandering river (Taken from USDOI-FWS, 1980b).

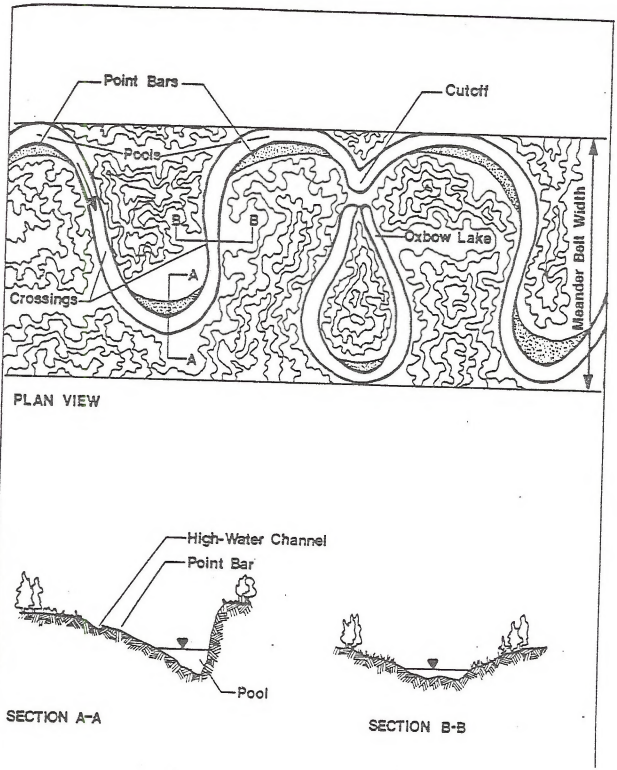
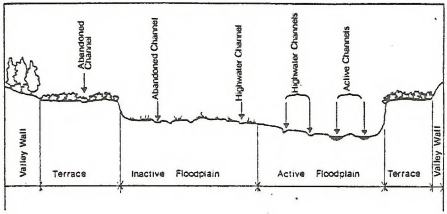


FIGURE 4 . Floodplain locations (Taken from USDOI-FWS, 1980a).



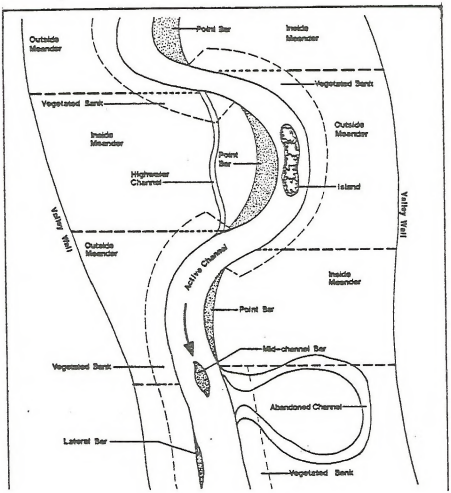
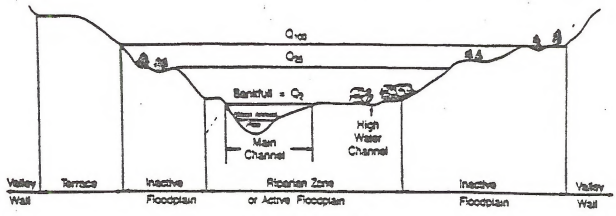
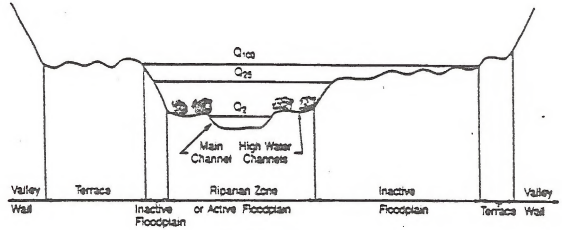


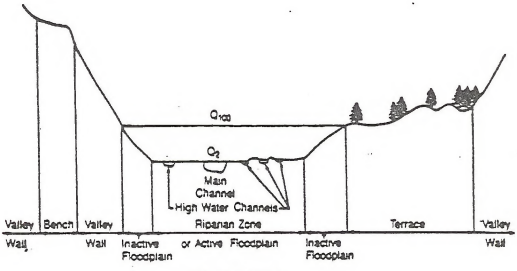
FIGURE 5 . Cross section sketches defining stream topographic features (Rundquist et. al., 1986).



MEANDERING STREAM



MOUNTAIN STREAM



BRAIDED STREAM

CROSS-SECTION SKETCHES DEFINING TOPOGRAPHIC FEATURES

ENTRIX | Figure 30

FIGURE 6 . Schematic diagram illustrating definitions of channel geometric and hydraulic variables (Taken from USDOI-FWS, 1980b).

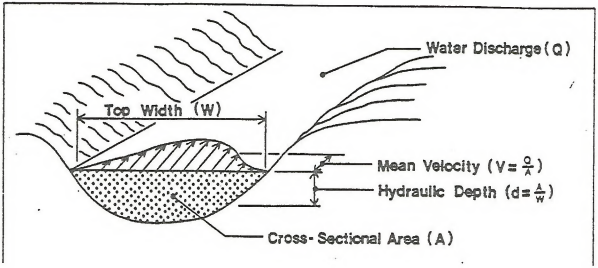
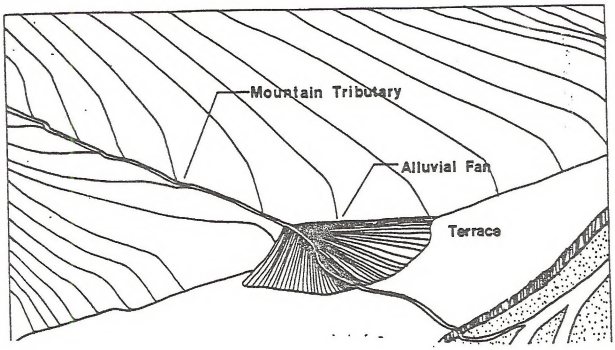


FIGURE 7 . Schematic diagram of an alluvial fan.
(Taken from USDOI-FWS, 1980b)



WHAT SHOULD BE IN A RECLAMATION PLAN?

The plan should adequately discuss the intended methods and procedures for reclaiming the disturbed area, removal or leaving of permanent structures such as camps or river training dikes, and whether access is to be kept open after the site is reclaimed - which influences the required design life of the access road.

DEVELOPING THE "UNNECESSARY OR UNDUE" DEGRADATION DEFINITION FOR A SITE

Both the operator and the BLM will be trying to ascertain what "unnecessary or undue" degradation means at each site. This determination requires the following baseline information to be developed, at least generally, for each site:

a. Known biological resources of the general vicinity, including fishery resources of the subject river system.

b. Timing of major fish and wildlife life-cycle events and presence of limiting habitat occurring in the vicinity of the site.

c. Hydraulic characteristics (such as channel configuration and discharges) in the vicinity of the mine.

d. Cultural resources.

TYPES OF MAPS WHICH ARE DESIRABLE

The maps of an operation should include, whenever possible, detailed sketches, ground photographs, topographic maps and, if available, aerial photography showing, as appropriate:

a. Accurate claim boundaries;

b. Past, present and future work areas;

c. Any buffer areas to be left undisturbed, in order to minimize impacts on active channels;

d. Locations of all site-related temporary and permanent structures planned, such as access roads, airstrips, camps, river diversion and/or training structures, bank protection devices, stockpiles, tailings pile, processing area, overburden piles, etc.

DELINEATING THE DISTURBED AREA

It would be very helpful for either the operator or the BLM field personnel to:

a. Flag the boundaries of present disturbed areas and proposed future expansion areas, so that the operator and BLM can agree and document the areas where operations and reclamation are to occur;

b. Establish and mark (flag) reference points on the site to record/estimate the height of aufeis buildup, spring breakup runoff or other flood events in the vicinity so that operations can be optimized, while minimizing environmental impacts.

MINIMIZING SURFACE DISTURBANCE DURING INITIAL PHASES OF WORK

(Adapted from USDOI-FWS, 1980a)

Prior to opening a new site or expanding an existing site, the operator and BLM should give some thought to minimizing surface disturbance, and to needed reclamation. The following suggestions are provided to minimize initial disturbance:

a. If possible, place all test pits to avoid crossing or working in an active channel.

b. Schedule activities to avoid conflict with predictable flood periods and major fish and wildlife use of an area.

c. Avoid disturbing vegetated areas if test pits can be made in unvegetated areas. By using unvegetated areas, additional sediment runoff should be minimized, along with helping reclamation / revegetation requirements.

d. If vegetated areas cannot be avoided, favor small disturbances within large stands of homogeneous, mature vegetation where habitat diversity will be increased by the disturbance, rather than disturbing riparian or other edge habitats of limited availability where reclamation and revegetation will be more difficult.

e. With regard to the exploration for/development of mineral deposits, such activities are inherently likely to require significant disturbance in areas where this may be less-than desirable from an environmental degradation standpoint. Careful planning, mitigation and reclamation will be essential in such situations.

MINIMIZING SURFACE DISTURBANCE DURING OPERATIONS

(adapted from USDOI-FWS, 1980a)

When a choice exists, conduct operations and all ancillary activity so as to:

a. Avoid any activity in an active channel.

b. Maintain a buffer of undisturbed land between active channels and the operation.

c. Avoid excavating to depths or in locations that will induce permanent channel alteration or ponding of water.

d. Avoid constructing any river training or bank protection devices since they may disrupt natural stream processes/balances and may result in scour and erosion elsewhere in the stream system.

e. Avoid disturbance of natural banks.

f. Avoid clearing of riparian vegetation.

MINIMIZING FISH AND WILDLIFE HABITAT DISTURBANCE

(Adapted from USDOI-FWS, 1980a)

Where a choice exists, operations in the following areas should be done very carefully or not at all, in order to minimize or eliminate disturbances:

a. Critical habitat of threatened or endangered species, as designated by State and/or Federal agencies.

b. Fish and wildlife habitats limiting local populations, such as fish and wildlife breeding, nesting, spawning, lambing or calving areas and along major migration routes.

c. Active river channels. Oftentimes, as in many mining operations, avoidance is not possible.

d. Springs.

e. Wetlands.

BUFFERS

(Adapted from USDOI-FWS, 1980a)

Buffers are areas of undisturbed ground surface designed to maintain the integrity of adjacent active river or stream channels and minimize change, including siltation, to the aquatic habitat. There is no set width for a buffer, but important variables to consider in the selection of buffer location, width and elevation include:

a. Configuration of the adjacent channel.

b. Channel size.

c. Local hydrologic characteristics.

d. Channel aufeis.

e. Permafrost or ice-rich stream banks.

f. Type of local vegetation.

g. Soil composition.

TOPSOIL

Topsoil (such as may be present) must be saved for final application after reshaping of disturbed areas has been completed. This means that the operator and BLM will have to determine both what constitutes "topsoil", and how to best store it at each site. At a minimum, topsoil in Alaska should be thought of as all of the active organic layer, plus as much of the subsoil (even where not really "topsoil", in the usual sense) as appears capable of supporting plant growth. In actual practice, the operator should save all of the top organic layer if present and the subsoil as feasible. If less than six inches thick, it may be difficult to salvage with mechanical methods. One knowledgeable specialist offers the following comments:

> "In Alaska, topsoil is a loosely defined term alluding to litter, organic mat and the A and B horizons. A term such as "original surface material to a depth of _?_ inches" may be more appropriate. Very few trained people will argue against the fact that this surface material is probably a better growing medium as well as a source of seed and other propagules. The fact remains that stockpiling and redistributing this material is a technical and costly operation. This material, if not handled properly, may cause more serious problems than the stripped area.

For example: a stable, gravelly area may be classified as having a low potential for erosion. When the organics and silts are reapplied to the gravelly area, the erosion potential may be classified as significant. This increase may cause the miner to respond with additional work (I believe these situations are called a "catch 22" or a "no win" situation). Not only may the veneer of "topsoil" cause an erosion problem, but the stockpile prior to redistribution could become a source of sediment."

In general, the best approach would seem to require that, in order to save and protect the fertility of the topsoil for use in reclamation, the operator should:

a. Separate and properly dispose of all large woody material from the topsoil to be saved.

b. Store the topsoil in piles away from the active channel, in locations where the topsoil will not have to be rehandled or disturbed in any way prior to respreading.

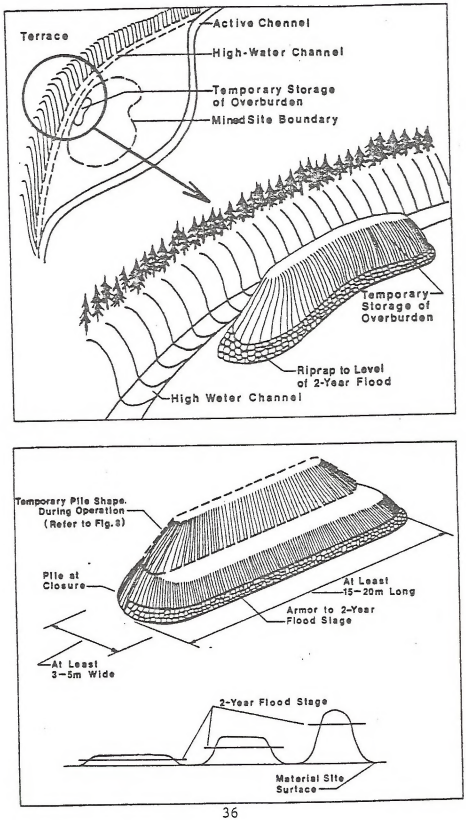
c. Construct the piles to prevent slope failures and minimize erosion.

d. Make the piles long and narrow and oriented parallel to the flow of the active channel, if in the floodplain.

e. Make sure the piles are of sufficient height and have sufficient armouring at the toe to withstand spring breakup flows and at least the two-year flood event. Use moderate slope gradients in order to minimize erosion.

Figure 8 illustrates this.

FIGURE 8 . Typical view of desireable topsoil storage stockpile shape, configuration, location and armor protection (Taken from USDOI-FWS, 1980a).



USING TOPSOIL DURING RECLAMATION

(Adapted from USDA-FS, 1980)

There are two major purposes for saving and respreading topsoil during reclamation:

a. In most cases, topsoil will provide the best growth medium for plants.

b. Topsoil will provide better infiltration and less surface runoff of water and, hence, less erosion.

FACTORS WHICH INFLUENCE EROSION

(Adapted from USDA-FS, 1979b)

For a given climate setting, erosion rate is influenced by:

a. Types of materials on the site.

b. Steepness and length of slopes.

c. Drainage and water control structures provided.

d. Amount of vegetation or surface roughness on slopes.

TREATMENTS WHICH WILL REDUCE EROSION

(Adapted from USDA-FS, 1979b)

High erosion rates may be treated with:

a. Surface manipulation.

b. Mulching.

c. Proper timing of topsoil replacement and revegetation.

EFFECTS OF SURFACE DISTURBING ACTIVITIES ON FISHERIES

(Adapted from USDA-FS, 1980)

Fisheries can be affected by:

a. Widening, scouring, or filling in of stream channels.

b. Diverting stream flows.

c. Increasing suspended sediment, dissolved solids load and sediment bedload.

d. Disrupting stream banks.

e. Eliminating or changing riparian vegetation species composition.

f. Adding toxic materials to the water.

DEALING WITH TOXIC MATERIALS

Each operation generally will produce toxic substances, such as crankcase oil, sewage, etc. and some may also uncover potentially toxic natural substances (e.g. sulfide minerals subject to degradation upon exposure). All use of the public lands must be conducted in an environmentally acceptable manner, which means:

a. All fuels and other toxic materials should be stored out of the floodplain.

b. Fueling and servicing of equipment within the floodplain should be avoided to reduce spills of fuel, lubricants and waste oil such as spent crankcase oil.

c. The effluents from support activities occurring on or near the operation, such as gray water, domestic sewage and solid waste, should be disposed of as required under applicable State and Federal Regulations, and should not be disposed of within the floodplain without proper treatment and approvals.

CONTROLLING DRAINAGE ON THE SITE

(Adapted from Rundquist et. al., 1986)

Proper drainage control requires identification of all sources of water on a site, as well as the sources of erosion, so that the operation can be planned and carried out from beginning to end so as to minimize erosion and pollution of receiving waters. A properly functioning drainage system acts to divert clean water around an operation, as well as retaining and treating any operations-related sediment-laden water within the site. Figures 9 - 13 illustrate relevant features.

FIGURE 9 . Stream diversion channel construction (Rundquist et. al., 1986).

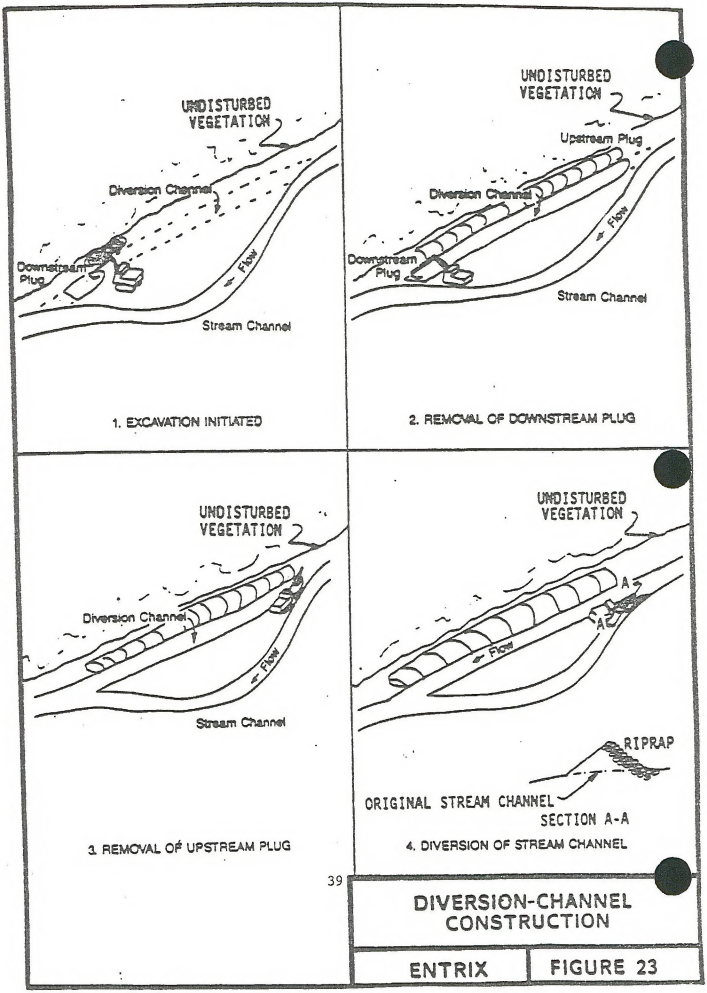
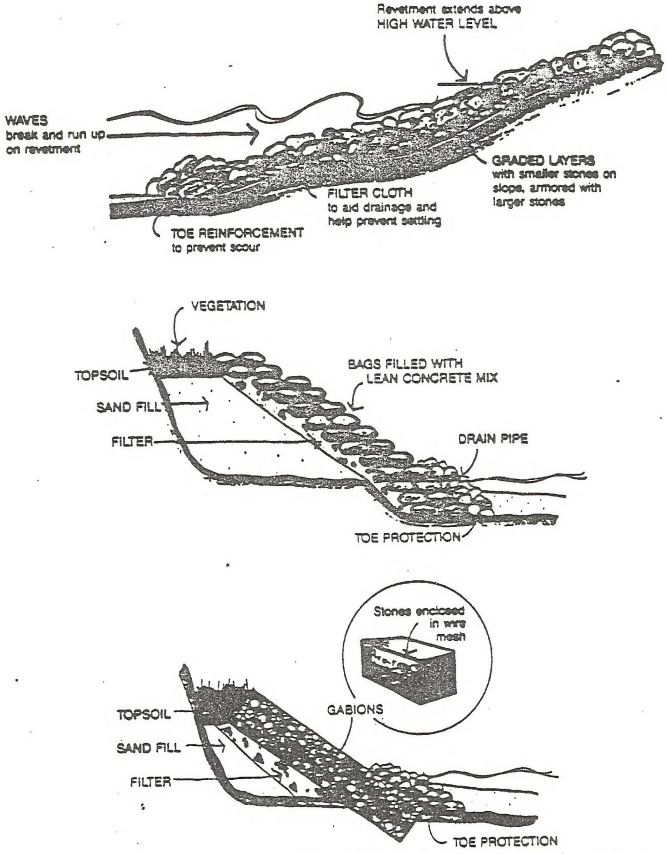


FIGURE 10 . Methods of achieving bank stability (Rundquist et. al., 1986).

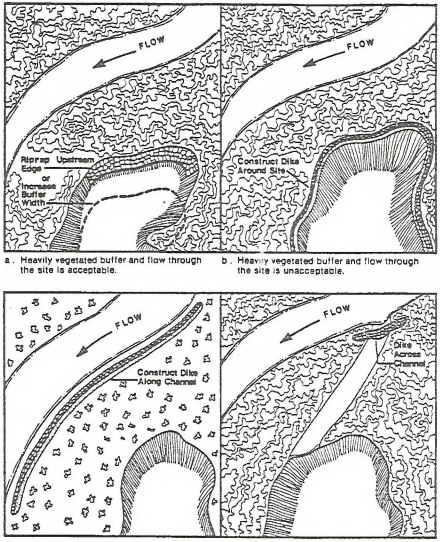


BANK STABILITY

SOURCE: U.S. Army Corps of Engineers 1981

ENTRIX | Figure 65

FIGURE 11 . Schematic of recommended options if the probability of flow through the site is high (Taken from USDOI-FWS, 1980a).



a. Heavily vegetated buffer and flow through the site is acceptable.

b. Heavily vegetated buffer and flow through the site is unacceptable.

c. Lightly vegetated buffer and flow through site is acceptable.

d. Highwater or abandoned channel through heavily vegetated buffer and flow through site is acceptable.

FIGURE 12 . Dike design considerations (Taken from USDOI-FWS, 1980a).

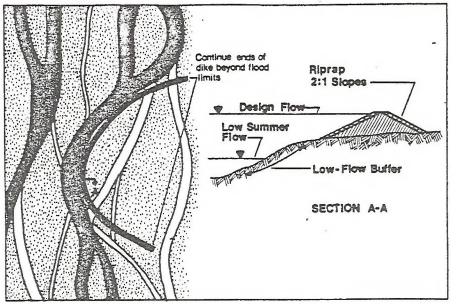
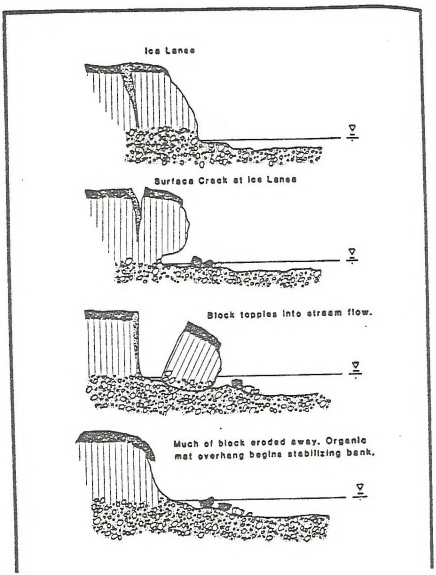


FIGURE 13 . Stream scour erosion in ice-rich banks (taken from Mahmood, Barrett and Schlegel, 1986).


Ice Lense
Surface Crack at Ice Lense
Block topples into stream flow.
Much of block eroded away. Organic mat overhang begins stabilizing bank.

In general, proper drainage control measures include:

a. Proper diversion of stream channels and off site overland flow around operations -- There is no reason operators should try to remove sediment from any water not muddied directly or indirectly by their operations. One of the first steps in opening a new site should be to divert any active stream channels and off site overland flow around the operation, and to protect the area with berms, in order to lessen the amount of water intercepted and requiring treatment. The diversion should be planned, constructed and operated to avoid excessive erosion or deposition of sediment, to contain floods within the range of acceptable risks, and to allow for fish passage in a fish stream. The diversion channel should be inspected frequently, and maintained as necessary.

b. Interception and diversion of ground water around the operation -- The amount of water passing through a settling pond may be substantially increased by groundwater seeping into the operations area and through the settling pond, if located in a low-lying area. However, just as surface streams may be diverted around an operation, it is also permissible to cut-off trench and intercept any groundwater (which might otherwise surface in the operation, where it would have to be routed through the settling pond) and lead it to surface waters bypassing the site. As with surface diversions, the interception and diversion must not adversely impact upon water quality.

c. Proper overburden removal, placement and protection of storage stockpiles -- Proper removal, segregation and stockpiling of overburden - including vegetation, organic and inorganic components - should be performed just prior to processing the underlying materials/deposits, in order to limit the time period during which erodable slopes are exposed. It may be necessary to encircle the operations with containment berms/dikes to collect runoff from stripped slopes and route it through the settling pond. Storage stockpiles sometimes may need to be armored. As feasible, they should be placed in areas where they will not need to be rehandled, and where they can be protected from erosion. Vegetative materials may be considered for use as armor, and in dikes. Stockpile slopes should be minimized, as feasible, to minimize erosion. Storage stockpiles of highly erodable material should be stabilized, - by seeding and fertilizing if necessary, to prevent erosional losses.

d. Proper grading and shaping of spoil -- Grading and shaping of spoil, and reduction of tailings piles concurrently with operations will not only reduce erosion but also ease overall site reclamation. If tailings are properly placed and graded during operations, additional grading may not be necessary upon site closure. Constructing floodplain terraces and furrows parallel to the contours of steep side slopes will reduce the effective length of erodable slopes, thereby limiting erosion and slope failure.

e. Adequate settling pond systems -- Settling ponds are used to clarify water draining from mining and other types of surface disturbing operations. Location of the settling pond(s) should be one of the most important physical parameters considered during planning for the operations. In general, settling ponds should be:

1. Located above the groundwater table to prevent seepage into the pond.

2. Designed to obtain enough water residence time to allow fine sediment to deposit.

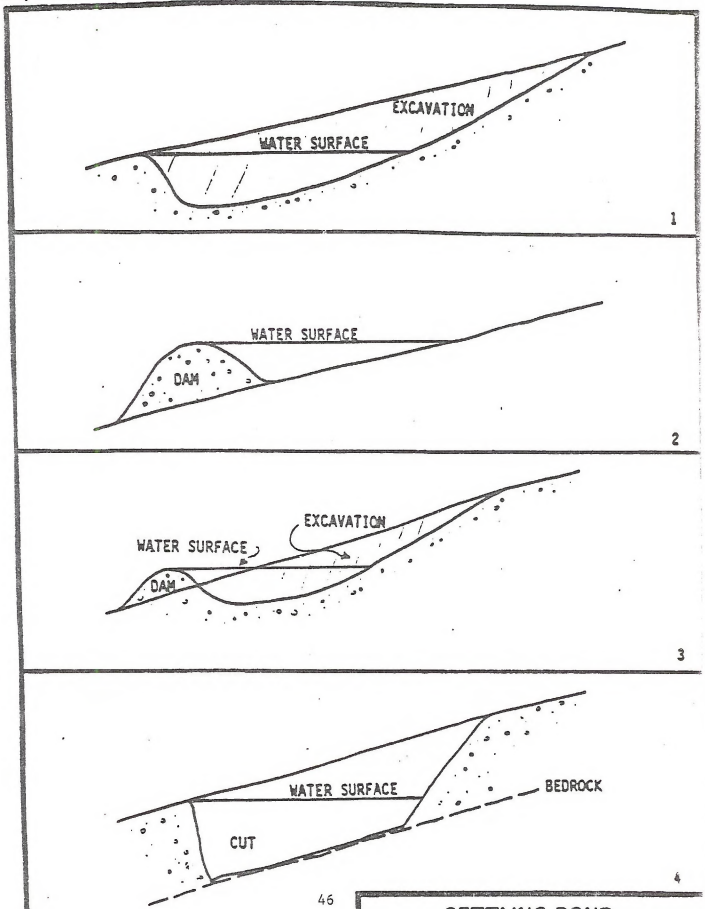
3. Designed to allow for easy removal of accumulated sediment, or construction of a new settling pond to replace one nearing 60% of capacity.

4. Designed for easy reclamation by dewatering/removal of sediment, filling, or leaving as fishery habitat, as applicable and approved.

SOME INFORMATION ABOUT SETTLING PONDS

Whether they are called settling ponds, sediment ponds, stilling basins, filter ponds, siltation control ponds or some other name, the use of settling ponds has been the principle technique used to attempt to prevent degradation of water quality for many mining and other types of operations in Alaska. Alternative techniques are presently being evaluated, including a variety of "total recycling" methods, and various lines of research are being pursued by various groups on other innovative schemes (e.g. mobile washing plants and gravel filters; tank flocculation; etc.) as well. For the time-being, however, the settling pond approach remains an essential ingredient in many, if not most operations in Alaska. Settling ponds may or may not in fact represent "best available technology"; this issue is somewhat controversial, and such generalizations are difficult to sustain in any event. Economic considerations will be a major factor as well, in any situation, together with new technology. If a settling pond system is properly planned, constructed and operated, it should be capable of removing at least the coarser fraction of soil particles in the effluent stream and should also reduce wastewater turbidity. BLM does not recommend specific design criteria, as long as unnecessary or undue degradation is prevented, an operator may construct essentially any type of structure desired. The Alaska Dept. of Environmental Conservation's (1987) Placer Mining Demonstration Grant Project Design Handbook presents materials which may be useful in certain situations. Figures 14 - 18 illustrate significant features of concern.

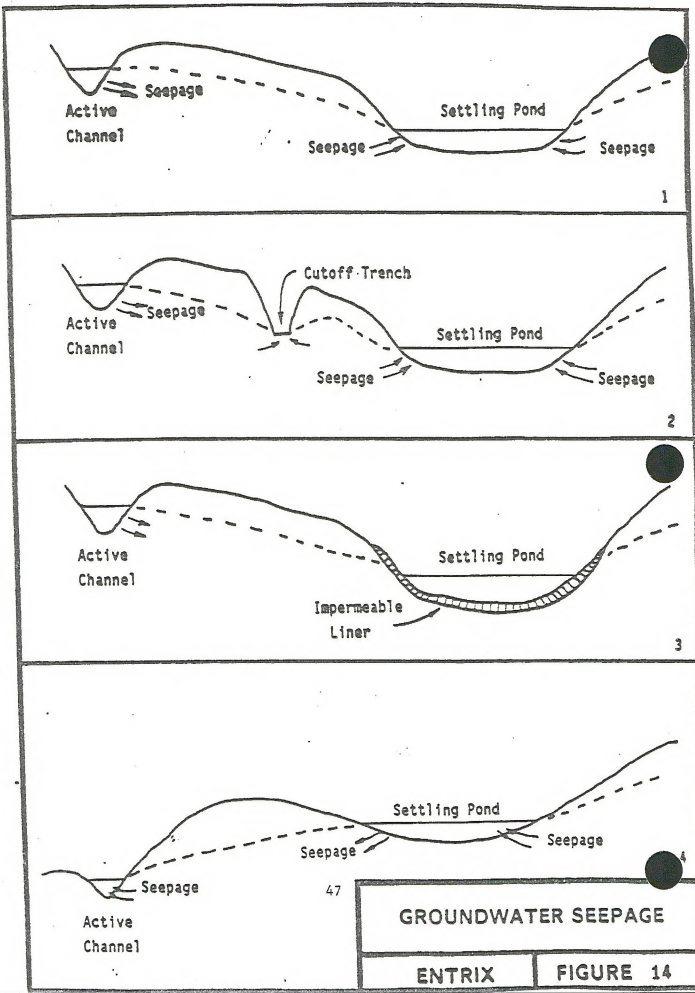
FIGURE 14 . Some simple settling pond construction options (Rundquist et. al., 1986).



SETTLING-POND CONSTRUCTION OPTIONS

ENTRIX | FIGURE 15

FIGURE 15 . Groundwater seepage into a settling pond (Rundquist et. al., 1986).



GROUNDWATER SEEPAGE

ENTRIX | FIGURE 14

FIGURE 16 . Schematic of alternatives to overflow discharge from settling ponds (USDA-FS, 1979a).

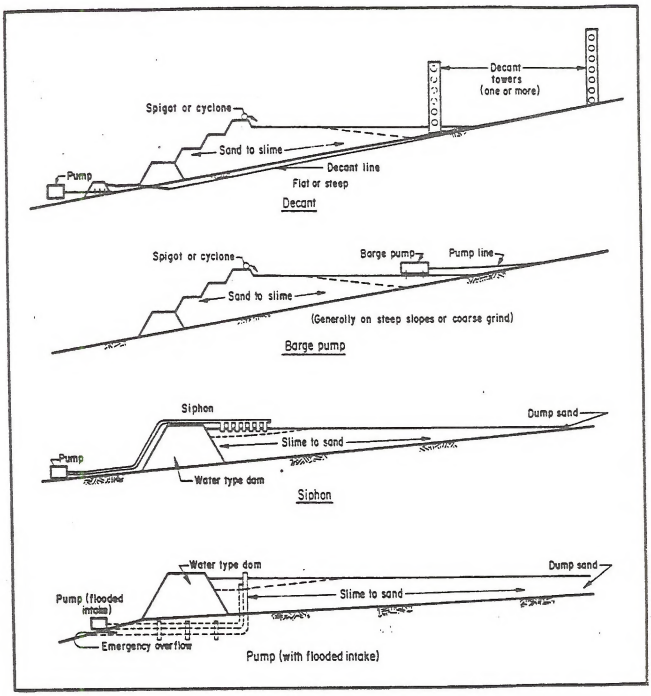


FIGURE 17 . Example placer mine settling pond layout (Alaska DEC, 1983)

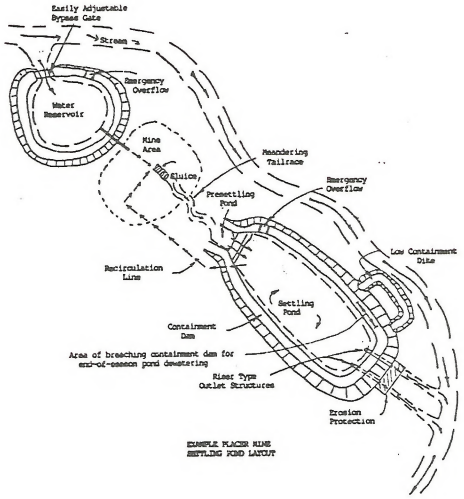
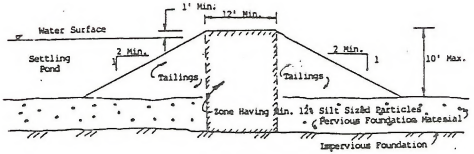
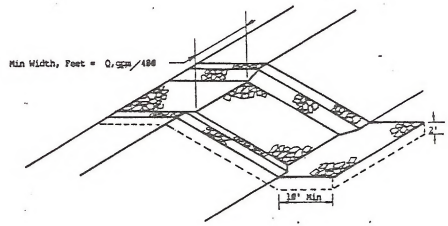


FIGURE . Typical section of containment dam (Alaska DEC, 1983)

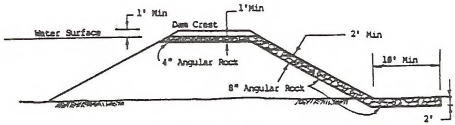


TYPICAL SECTION OF CONTAINMENT DAM

FIGURE 18 . Overflow spillway construction (Alaska DEC, 1983)

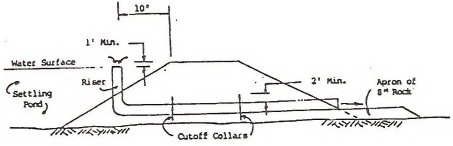


TYPICAL OVERFLOW SPILLWAY CONSTRUCTION



OVERFLOW SPILLWAY SECTION

FIGURE . Typical rise type outlet (Alaska DEC, 1983)



TYPICAL RISER TYPE OUTLET

In addition, some basic concepts include:

a. Before anything else, make sure that the operation has diverted as much water as possible around the active area, and that operations will be done using the least amount of water possible, in order to limit the amount of water needing treatment.

b. Make a field reconnaissance of the general site area to :

   1. Determine how much surface runoff, groundwater and stream flow above the site could be diverted around the activity area. Review the operating and processing methodology to insure that operations will be carried out using the least amount of water possible, to limit the amount of water needing treatment. Recycling of process water through a small sump to remove coarse sediments may be sufficient to supply all the water needed at the processing plant, with minimal effluent.

   2. Determine internal site drainage patterns, and estimate high flow.

   3. Make preliminary layout sketches, and compute the volume and economics of all alternatives capable of handling the expected site drainage.

   4. Select the most favorable alternative. Analyze the on-site building materials.

   5. Analyze the settling pond's embankment geometry.

   6. Prepare construction sketches and estimate all specifications.

c. During the planning process, remember that several small ponds are usually better at removing sediment than one huge pond.

d. A long tailrace from processing equipment to the first settling pond will help settle out coarser tailings and other particles before they are deposited in a pond, where removal is more difficult.

e. All sediment ponds must avoid fish entrapment.

f. If ponds are to be placed in the floodplain, they should be protected with dikes designed for at least the 10-year flood.

There are several types of ponds used in water treatment strategies (adapted from USDOI-FWS, 1980a). These include:

a. Settling Ponds -- Pond With Outlet. These ponds require:

   1. A large cross-sectional area so that the horizontal velocity of water is very low.

2. Water to enter the pond over most of the width to make the entire pond effective, and to avoid "short-circuiting" and channel formation.

3. The settling pond outlet to be wide to skim off the top clear water while maintaining a low horizontal velocity.

b. Filter Ponds -- Pond Without Outlets. If the surface material on a mine is suitable, it may be possible to build a pond with no outlet that will allow outflow by filtration through the substrate. Some parameters include:

1. The water table below a filter pond must be low enough that water will filter out of, not into, the pond.

2. The walls and bottom of a filter pond must be porous enough to allow outflow. The pond should be kept full so that the entire pond, walls and bottom, are working, to prevent premature sealing.

3. Filter ponds must be large enough to prevent premature clogging with fines.

4. Coagulants should not be used in filter ponds as they will shorten pond life.

5. It is best to use a filter pond in series with a preceding settling pond to remove heavy particles.

c. Coagulation Pond -- Artificially Speeding Settlement. A coagulation pond is any type of pond to which coagulants are added to speed up settling of sediment. Here are some recommendations:

1. Coagulants should be used when there is a high concentration of solids that will not settle out and/or where there is a limited area for settling ponds.

2. Coagulants must be thoroughly mixed into the inlet water to be most efficient. Experience has shown that this is very important.

3. Many coagulants work best in warm water, with the basic settlement rate increasing substantially with increase in temperature. Others are equally effective over a broad range of temperature.

4. Coagulants are most effective when used in a series of ponds.

5. Coagulants should be added at the inlet of each pond to maximize exposure to the sediment, although if the initial mixing is done properly, the coagulants should only need to be added at the one point in the system.

6. Commonly used coagulants include: Aluminum sulphate (alum), ferrous sulphate, calcium hydroxide (hydrated lime), calcium oxide (quick lime), sodium aluminate, sodium carbonate (soda ash), ferric chloride and sodium silicate.

Various agencies (U.S. Bureau of Mines, Environmental Protection Agency) are presently investigating aspects of the use of coagulants (particularly "PEO" - polyethylene oxide). Alternate technologies are being developed which may eliminate the need for settling ponds in treating waste water.

DEALING WITH AUFEIS

Once aufeis begins to develop on a stream reach, most control options are gone. Basically, the best defense against aufeis is to design diversion channels or berms around an operation, with enough freeboard to provide for aufeis buildup. In winter, bedrock groundwater drains may reduce the potential for aufeis in areas downstream.

CARRYING OUT OPERATIONS WITH MINIMAL DEGRADATION OF THE ENVIRONMENT

There are no all-encompassing environmental "rules or laws" governing producing the least amount of degradation. There are, however, general recommendations that can be reviewed after a specific site's characteristics are known. If at all feasible to the operation, generally it would be best to:

a. Block off and mine active side channels rather than the main channel.

b. Scrape unvegetated placer gravels no lower than the water level present during a mining operation in order to maintain the integrity of the low-flow channel.

c. Exclude vegetated islands in the floodplain from active operations.

d. Exclude disturbance of vegetated river banks of both active and high-water channels.

e. Not increase channel-full top width of any active channel.

APPENDIX IV.

THE OPERATION

Included in this appendix are several references considered to be particularly relevant to the preceding discussion in Chapter IV. The technologies discussed have been demonstrated to be technically sound, but there has been appreciable public discussion of the feasibility/practicality of applications in at least some situations commonly encountered in Alaska. This controversy remains largely unresolved at the present time. As they stand, these documents represent valuable reference materials in terms of illustrative technology, which may or may not be appropriate in any particular instance, and are presented here solely in this context.

Bureau of Land Management
Riparian Area Management Policy

BACKGROUND

Riparian areas are unique and among the most productive and important ecosystems, comprising approximately 1 percent of the public lands. Characteristically, riparian areas display a greater diversity of plant, fish, wildlife, and other animal species and vegetation structure than adjoining ecosystems. Healthy riparian systems filter and purify water as it moves through the riparian zone, reduce sediment loads and enhance soil stability, provide micro-climate moderation when contrasted to extremes in adjacent areas, and contribute to groundwater recharge and base flow.

DEFINITIONS

Riparian Area - an area of land directly influenced by permanent water. It has visible vegetation or physical characteristics reflective of permanent water influence. Lake shores and stream banks are typical riparian areas. Excluded are such sites as ephemeral streams or washes that do not exhibit the presence of vegetation dependent upon free water in the soil.

Riparian Area-Dependent Resources - resources such as water, vegetation, fish, and certain wildlife that owe their existence to the riparian area.

OBJECTIVE

The objective of riparian area management is to maintain, restore, or improve riparian areas to achieve a healthy and productive ecological condition for maximum long-term benefits.

POLICY STATEMENTS

In order to meet the foregoing objective, the Bureau will to the extent practical:

- Achieve riparian area improvement and maintenance objectives through the management of existing uses wherever feasible.
- Ensure that new resource management plans and activity plans, and existing plans when revised, recognize the importance of riparian values, and initiate management to maintain, restore, or improve them.
- Prescribe management for riparian values that is based upon site-specific characteristics and settings.
- Give special attention to monitoring and evaluating management activities in riparian areas and revise management practices where site-specific objectives are not being met.
- Cooperate with and encourage the involvement of interested Federal, State, and local governments and private parties to share information, implement management, coordinate activities, and provide education on the value, productivity, and management of riparian areas.
- Retain riparian areas in public ownership unless disposal would be in the public interest, as determined in the land use planning system.
- Identify, encourage, and support research and studies needed to ensure that riparian area management objectives can be properly defined and met.

Robt J Burford
Director, Bureau of Land Management

JAN 22 1987
Date

Best Management Practices for Placer Mining Reference Manual

by
Entrix, Inc.

Principal Authors:
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N.E. Bradley
J.E. Baldrige
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January 1986

TABLE OF CONTENTS

Page

ACKNOWLEDGEMENTS

1.0 INTRODUCTION..... 3
1.1 OBJECTIVE..... 3
1.2 SCOPE..... 5
1.3 REPORT ORGANIZATION..... 7

MINING PLAN

2.0 MINING PLAN..... 13
2.1 PRE-MINING SITE CONDITIONS..... 15
2.2 SITE PLANNING AND DESIGN..... 17
2.2.1 General..... 17
2.2.2 Site Preparation..... 19
2.2.3 Site Operation..... 21
2.2.4 Site Closure and Rehabilitation..... 23

NONPOINT-SOURCE POLLUTION CONTROL

3.0 INTRODUCTION TO NONPOINT-SOURCE POLLUTION CONTROL..... 29
3.1 OBJECTIVE AND SCOPE..... 29
3.2 SUMMARY..... 31

4.0 DRAINAGE CONTROL..... 35
4.1 OBJECTIVES AND APPROACH..... 35
4.2 SETTLING PONDS..... 37
4.2.1 Settling-Pond Siting..... 39
4.2.2 Settling-Pond Design..... 43
4.2.3 Settling-Pond Construction..... 43
4.2.4 Settling-Pond Operation..... 43
4.2.5 Settling-Pond Rehabilitation..... 45
4.3 STREAM CHANNEL DIVERSION..... 49
4.3.1 Diversion-Channel Siting..... 49
4.3.2 Diversion-Channel Design..... 51
4.3.3 Diversion-Channel Construction..... 63
4.3.4 Diversion-Channel Rehabilitation..... 63
4.4 BEDROCK DRAINS..... 65
4.5 OVERLAND FLOW..... 67

5.0 SITE GRADING..... 71

6.0 STOCKPILE PLACEMENT AND PROTECTION..... 77

SITE REHABILITATION

7.0 INTRODUCTION TO SITE REHABILITATION..... 85
7.1 OBJECTIVE AND APPROACH..... 85
7.2 SUMMARY..... 87

TABLE OF CONTENTS
(Continued)

Page

8.0 STREAM REHABILITATION..... 91
8.1 OBJECTIVES AND APPROACH..... 91
8.2 DESIGN FLOWS..... 93
8.2.1 Risk Assessment and Recurrence-Interval Selection..... 93
8.2.2 Design Flow Computation..... 93
8.3 STREAM PATTERN AND PLACEMENT.....107
8.3.1 Definitions.....107
8.3.2 Selection of Stream Pattern.....109
8.3.3 Stream Length.....119
8.3.4 Placement of Stream Pattern.....121
8.3.5 Stream Bed Elevation.....121
8.4 HYDRAULIC DESIGN.....123
8.4.1 Meandering-Stream Design.....123
8.4.2 Mountain-Stream Design.....131
8.4.3 Braided-Stream Design.....141
8.5 CHANNEL STABILITY.....143
8.5.1 Bed Stability.....143
8.5.2 Bank Stability.....145
8.5.3 Riprap Design.....147

9.0 FISH HABITAT REHABILITATION.....155
9.1 OBJECTIVES AND SCOPE.....155
9.2 FISH HABITAT COMPONENTS.....157
9.3 HABITAT REQUIREMENTS.....157
9.4 HABITAT DESIGN FOR FISH STREAMS.....159
9.4.1 Rock Island.....161
9.4.2 Boulder Grouping.....163
9.4.3 Submerged-Rock Weir.....165
9.4.4 Tree Cover.....167
9.4.5 Wing Deflectors.....169
9.4.6 Overhanging Bank Cover.....171

10.0 FLOODPLAIN REHABILITATION.....175
10.1 OBJECTIVES AND SCOPE.....175
10.2 SITE GRADING.....177
10.2.1 Riparian Zone.....179
10.2.2 Inactive Floodplain.....185
10.2.3 Valley Terrace.....189
10.2.4 Valley Bench.....189
10.3 STOCKPILE DISPERSEMENT.....191
10.4 REVEGETATION.....199

APPENDIX B GLOSSARY.....203

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Best Management Practices for Placer Mining Technical Report

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TABLE OF CONTENTS

Page

ACKNOWLEDGEMENTS

1.0 INTRODUCTION 1
1.1 OBJECTIVE 1
1.2 SCOPE 2
1.3 REPORT ORGANIZATION 3

MINING PLAN

2.0 MINING PLAN 9
2.1 PRE-MINING SITE CONDITIONS 11
2.2 SITE PLANNING AND DESIGN 13
2.2.1 General 13
2.2.2 Site Preparation 14
2.2.3 Site Operation 16
2.2.4 Site Closure and Rehabilitation 17

NONPOINT-SOURCE POLLUTION CONTROL

3.0 INTRODUCTION TO NONPOINT-SOURCE POLLUTION CONTROL 23
3.1 OBJECTIVE AND SCOPE 23
3.2 SUMMARY 24

4.0 DRAINAGE CONTROL 31
4.1 OBJECTIVES AND SCOPE 31
4.2 SETTLING PONDS 32
4.2.1 Settling-Pond Siting 33
4.2.2 Settling-Pond Design 35
4.2.3 Settling-Pond Construction 36
4.2.4 Settling-Pond Operation 36
4.2.5 Settling-Pond Rehabilitation 37
4.3 STREAM CHANNEL DIVERSION 38
4.3.1 Diversion-Channel Siting 38
4.3.2 Diversion-Channel Design 39
4.3.3 Diversion-Channel Construction 48
4.3.4 Diversion-Channel Rehabilitation 50
4.4 BEDROCK DRAINS 50
4.5 OVERLAND FLOW 53

5.0 SITE GRADING 59
5.1 OBJECTIVES AND SCOPE 59
5.2 PROGRESSIVE SITE GRADING 59

6.0 STOCKPILE PLACEMENT AND PROTECTION 65
6.1 OBJECTIVES AND SCOPE 65
6.2 STOCKPILING 65

SITE REHABILITATION

7.0 INTRODUCTION TO SITE REHABILITATION 75
7.1 OBJECTIVE AND SCOPE 75
7.2 SUMMARY 75

TABLE OF CONTENTS
(Continued)

Page

8.0 STREAM REHABILITATION..... 83
8.1 OBJECTIVES AND SCOPE..... 83
8.2 DESIGN FLOWS..... 84
8.2.1 Risk Assessment and Recurrence-Interval Selection..... 85
8.2.2 Design Flow Computation..... 88
8.3 STREAM PATTERN AND PLACEMENT..... 92
8.3.1 Definitions..... 92
8.3.2 Selection of Stream Pattern..... 94
8.3.3 Stream Length.....100
8.3.4 Placement of Stream Pattern.....100
8.3.5 Stream Bed Elevation.....102
8.4 HYDRAULIC DESIGN.....105
8.4.1 Meandering-Stream Design.....105
8.4.2 Mountain-Stream Design.....114
8.4.3 Braided-Stream Design.....126
8.5 CHANNEL STABILITY.....128
8.5.1 Bed Stability.....128
8.5.2 Bank Stability.....131
8.5.3 Riprap Design.....131

9.0 FISH HABITAT REHABILITATION.....139
9.1 OBJECTIVES AND SCOPE.....139
9.2 FISH HABITAT COMPONENTS.....142
9.3 HABITAT REQUIREMENTS.....142
9.3.1 Anadromous Fish.....144
9.3.2 Resident Fish.....151
9.4 HABITAT DESIGN FOR FISH STREAMS.....154
9.4.1 Meandering Streams.....157
9.4.2 Mountain Streams.....166
9.4.3 Braided Streams.....170

10.0 FLOODPLAIN REHABILITATION.....175
10.1 OBJECTIVES AND SCOPE.....175
10.2 SITE GRADING.....176
10.2.1 Riparian Zone.....177
10.2.2 Inactive Floodplain.....183
10.2.3 Valley Terrace.....188
10.2.4 Valley Bench.....188
10.3 STOCKPILE DISPERSEMENT.....190
10.4 REVEGETATION.....197

APPENDIX A REFERENCES CITED.....203

APPENDIX B GLOSSARY.....217

APPENDIX C MAPS OF MEAN ANNUAL PRECIPITATION.....227

PLACER MINING WASTEWATER TREATMENT TECHNOLOGY PROJECT

EXECUTIVE SUMMARY

BY:

SHANNON & WILSON, INC.
Fairbanks, Alaska

Prepared For:

State of Alaska
Department of Environmental Conservation
John M. Reeves, Project Manager

March 1985

EXECUTIVE SUMMARY

1.0 INTRODUCTION

The Alaska Department of Environmental Conservation contracted Shannon & Wilson, Inc. to conduct a study of placer mine wastewater recycling and alternatives. The comprehensive intent of the study was to:

(1) Apply the technical and economic costs and benefits of sluice water recycling to placer mining in Alaska to determine its effect on fine gold recovery and pollution control.

(2) Evaluate alternatives to recycling to compare their cost-effectiveness at increasing gold recovery and reducing water use and pollution.

(3) Determine the best achievable treatment process at the three primary active placer mines studied.

(4) Determine whether Alaska and federal water quality standards can be attained by mining practices covered in the study.

(5) Recommend promising alternative technologies that warrant further study.

The study consisted of a literature review (Phase 1); laboratory testing of chemicals for effluent clarification, pilot scale testing of the effects of recycled water on fine gold recovery, and data gathering at active placer mines in Interior Alaska (Phase 2); and analysis (Phase 3). A report concluded each phase, with the Phase 3 report the final synthesis of knowledge gained during the study.

2.0 PHASE 1 SUMMARY

Phase 1 was a review of the literature on sluice water recycling and other techniques that reduce the impact of placer mining on a stream's water quality. There was also a search for information on fine gold

recovery and how recycling affects it. Equally important was information on alternative technologies and economic information on costs and benefits. The derivation and initial description of a characteristic mining operation, to be used as a baseline case (no recycle) for the Phase 3 analyses, was accomplished. The characteristic mine is used to compare partial and total recycle with no recycle with respect to water quality, gold recovery, and costs.

With regards to water quality, the literature review was limited to the problem of water pollution from sluice boxes and other washing plants. The problems of water pollution from overburden removal and surface water runoff, and the biological effects of placer mine discharges, were not studied, nor were suction dredge operations and dam safety.

3.0 PHASE 2 SUMMARY

The primary purpose of Phase 2 was to provide data to assess the physical and economic feasibility of recycling, along with the water quality benefits. The secondary purpose was to assess alternative wastewater treatment practices. The phase included a laboratory study of flocculants, a pilot study of recycled water's effect on fine gold recovery, and field studies of working mines.

3.1 LABORATORY STUDY

Coagulants and flocculants were laboratory tested to determine their suitability and economic feasibility for improving water quality from placer mines. The coagulants and flocculants tested, their costs, and resulting water quality for various chemical dosages appear in Section 2.0 of the Phase 2 report.

A simplified, field usable, jar testing procedure was successfully used to mix polymer and sluice effluent samples. This procedure is recommended for miners needing to evaluate or control flocculants.

Placer mine effluents containing from 5,910 to 26,900 mg/L suspended solids with a clay-sized content of 10 to 36 percent and turbidity levels of 2,000 to 13,000 NTU were successfully treated by a wide range of flocculants and coagulants. The performance of the flocculants varied somewhat among samples, but all samples could be treated to a final turbidity level of about 10 NTU with at least one of the flocculants. The chemical costs per million gallons of water treated for the best performing flocculants indicate that it may be much more economical to attain a turbidity in the translucent 100 to 200 NTU range than at the 5 NTU level above background at streams with a background of 50 NTU or less presently sought by the Alaska Department of Environmental Conservation. Some of the flocculants only produced final supernatant turbidities in the 100 to 200 NTU range when moderate dosages were applied. The cationic flocculants performed well in nearly all trials with final supernatant turbidities in the 10 to 100 NTU range, but did so at dosages of 5 to 25 mg/L. The costs of the products tested ranged from $15.64 to over $250.00 per million gallons of effluent for effective treatment. This corresponds to $0.23 to over $9.00 per ton of suspended sediment removed. These costs only include the chemical costs, and the dosages do not reflect possible mixing inefficiency in the field.

3.2 PILOT TEST

The major purpose of the pilot study was to determine whether high suspended solids concentrations affect fine gold recovery. A pilot scale test facility was used to assess the effects of sluicing with water containing various levels of suspended solids ranging up to approximately 200,000 mg/L. The effects of different types of clay and various viscosities on fine gold recovery were also assessed.

Gold capture in the pilot test sluice box was not directly affected by suspended solids or specific gravity of the wash water. It appears that significant gold loss did not occur except in the high viscosity run where the gold migration may have been caused by the nature of the viscosity builder. The other test runs suggest a trend of slight

increase in gold migration with increasing viscosity or concentration of clay-sized particles. The washing effectiveness of the water was slightly less with wash water of a very high suspended solids and clay content, as compared with wash water of a moderately low suspended solids content. These conclusions are drawn from relatively few tests in a pilot scale facility and must be viewed in light of some limitations. One limitation is the range of test parameters, which incorporate conditions unlikely to be exceeded at Alaska mines using recycle. The ranges of the test parameters were: total suspended solids levels in the sluice influent from 30 to 192,000 mg/L; influent viscosities from 1.0 to 20.6 centipoise at the run temperature; and percentage of clay-sized particles in the solids of 1 to 53 percent. Other major limitations include using salted gold ranging in size from -30 to +60 mesh for all but the washing effectiveness tests, and a relatively low water duty in all tests, which resulted in very thorough sluicing.

3.3 FIELD STUDY

The field study portion of the project was intended to provide the primary source of data to evaluate recycling, including its feasibility to control water pollution, and its effects on equipment operation and maintenance.

Field studies were conducted at six mines employing zero recycle to essentially 100 percent recycle. These mines were located north of Fairbanks along the Steese Highway on Gilmore, Flume, Fish, Faith, Gold Dust, and Eagle Creeks. The mines on Gilmore, Fish, and Eagle Creeks were designated as primary sites and were studied more intensively than the other three sites. The amount of pay dirt processed by the various types of plants ranged from 25 to 210 cubic yards per hour and water use varied from 420 to 6200 gallons per minute. The water duty, or number of cubic yards of pay dirt washed per 1000 gallons, ranged from 0.26 to 3.0. These mines employed one to seven settling ponds for water pollution control. The Environmental Protection Agency's settleable solids criterion was met at all six mines, but none of the operations met the Alaska turbidity criterion.

Water quality, equipment, cost, and operational data were collected at each mine, and gold recovery data where provided by some of the miners. Information on water quality included flow, settleable solids, total suspended solids, turbidity, temperature, specific gravity, and viscosity at all mines and arsenic at one mine. Five to seven sampling stations were established at each mine site, depending on the layout of the mine. These stations generally included the upstream freshwater source or sources, sluice influent, sluice effluent, freshwater bypass (if applicable), final settling pond effluent, and 500 feet downstream from the final settling pond.

4.0 PHASE 3 SUMMARY

4.1 RECYCLE AND WATER QUALITY

Since most miners recycle water during shortages, recycle is technically and economically feasible for at least short periods of time. Other miners who successfully recycle for the entire season because of chronic water shortages demonstrate the feasibility of recycle at least at some sites. Partial recycle is technically feasible at most placer mines in Alaska. Recycle practices commonly employed during periods of low stream flow are inadequate for full season operation. Additional planning is required to recycle for an entire season. A properly designed recycle system will not have significantly higher equipment wear rates than a no-recycle system.

Because of water gain from unchanneled surface and subsurface flow, total recycle resulting in zero discharge for the entire mining season is technically infeasible at the mines studied during this project. At some sites, reduced discharge may be possible during part of the season. Extrapolation of these observations indicates that full season zero discharge is likely to be unattainable on a widespread basis in Alaska.

The cost of treatment with settling ponds is estimated to represent an average of 4 percent of total yearly operating costs. At the three primary study sites, it is estimated that partial recycle with a bypass

would increase total operating costs an average of 23 percent over the yearly operating costs with settling ponds. The water quality benef of a full bypass may not be economically justified at all sites. However, settling pond maintenance costs for systems with no excess water bypass are composed primarily of repairs needed due to flood damage.

The volume of water used for sluicing varies from a few hundred to many thousand gallons per minute. The highest water use occurs in conventional sluice boxes with no classification. Water use can be significantly reduced when classification is employed and/or by the use of alternative gold separation devices such as a jig.

At each of the six mines studied this summer, downstream water quality could have been improved to varying degrees through some combination of bypass, improved settling pond design or maintenance, and feed classification before the sluice box. At mines not using recycle, the use of properly constructed and maintained settling ponds, and/or the reduction of process water use combined with bypassing excess flows are critic steps in maximizing downstream water quality.

A comparison of water quality between no-recycle and recycle operations indicates that the best downstream water quality occurs with partial recycle and a bypass. However, this same technique also results in the worst settling pond effluent quality. The best settling pond effluent quality occurs when there is no recycle and no bypass. Consequently, miners are caught between federal and State criteria because federal criteria are applied at the effluent and State criteria are applied in the receiving stream.

The six study sites generally met settleable solids criteria with their existing operations, but exceeded turbidity criteria by two to three orders of magnitude. With respect to reducing effluent settleable solids levels, it appears that proper settling ponds are more important than the use of recycle.

Alaska and EPA water quality standards regarding turbidity are not attainable by any demonstrated or widely used mining practice, except in unique circumstances such as where large volumes of clear water are available for dilution. Attainable levels are at least 2 orders of magnitude above current standards. The use of recycle with minimal makeup water, and a large volume of bypassed water available for dilution, will achieve the lowest downstream turbidity levels.

The use of innovative technology to reduce water usage may not in itself improve water quality, due to the apparent reduced performance of settling ponds at higher influent suspended solids levels (and associated higher viscosities). Reducing the volume of water used to process a given amount of pay dirt simply concentrates the sediment in a smaller volume of water. Reduced water use together with a bypass to dilute the pond effluent may result in improved water quality. In a recycle system, reduction of makeup water volume (and hence the volume of effluent discharged) is more critical to downstream water quality than is the reduction of water used in processing.

None of the true alternatives to settling ponds--that is, mechanically assisted separation, coagulants/flocculants, or filtration--appear to be justified from a water quality or economic standpoint as a replacement for settling ponds as the primary means of solids and turbidity reduction at placer mines in Alaska. In laboratory tests, flocculants and coagulants have proven to be effective in reducing turbidity levels. However, field trials have yielded inconsistent results with respect to duplication of laboratory results. It may be more feasible and economically acceptable to achieve final turbidities in the translucent 100 to 200 NTU range with flocculants and coagulants than to meet existing turbidity criteria. Filtration of final pond effluent through tailings is useful as a final polishing step in turbidity reduction.

4.2 RECYCLE AND GOLD RECOVERY

Three factors and their pertinent characteristics that influence gold recovery are:

(a) The gold--its particle size and shape, porosity, and hydrophobicity (its resistance to combine with water).

(b) The sluice--its slope, length, width, riffles, and mat; the feed size and rate; the sluice loading; riffle packing; time between cleanups.

(c) The wash water--its washing effectiveness, the water duty (cubic yards of pay dirt per 1000 gallons of water), steadiness of flow, and viscosity.

Many of the gold recovery factors are interrelated. For example, riffle packing is a function of all the other sluice characteristics as well as the wash water characteristics.

The best technique for fine gold recovery in a sluice is one that optimizes the sluice and wash water characteristics. This includes feed classification, thorough washing, and a slow, steady feed of pay dirt. More information is required about the size of gold recovered in Alaska sluices to assess the amount of gold lost while using clear water and recycled water for sluicing.

Gold recovery in a pilot test sluice box was not directly affected by the suspended solids level or specific gravity of the wash water. However, the viscosity of the wash water may affect gold recovery. Viscosities as high as those which appeared to begin causing gold migration in the pilot tests were not observed at any of the field study sites. The pilot tests also indicate that high solids or clay concentrations may decrease the washing effectiveness of the wash water.

The effect of recycling on fine gold recovery has not been determined under controlled field conditions. However, there is evidence that recycling will require more frequent sluice box cleanups, and a decreased water duty.

There is evidence that alternative gold separation technologies would improve gold recovery at many Alaska placer mines. Whether or not increased recovery will offset the additional capital and operating costs of the alternative technology is likely to be highly site specific.

4.3 RECOMMENDATIONS FOR RECYCLE OPERATIONS

Based on the results of this study, the highest downstream water quality will be achieved by:

(a) The use of well constructed and maintained settling ponds.

(b) Minimizing the volume of effluent discharged from the pond system.

(c) Bypassing all excess water flows.

The use of recycle with as little makeup water as possible will reduce the volume of effluent more than many other water-reducing technologies.

With a recycle system, at least the recycle pond should be bypassed, and preferably all ponds should be bypassed. In addition, a properly designed multiple pond system should be used to allow adequate clarification of the recycle pond effluent. As little makeup water as possible should be used, consistent with maintaining viscosity within tolerable levels. Filtration through a properly graded tailings filter should be considered as a final polishing step for settling pond effluent.

Control of water gain should be considered when laying out a mine site. The excess water bypass should be located as far from the cut and ponds as possible and a catchment ditch should be considered for control of surface and shallow subsurface flow from the hillside opposite the bypass.

Ideally, settling ponds should not be cleaned during the summer because the disturbance creates an adverse impact on downstream water quali This is especially true when a dike is breached to allow solids to flow out of the pond, whether intentionally or because of floods. From field observations, a dragline may be the best method to clean a pond if it has to be done during summer. When solids disposal is necessary a practical method for removing solids from ponds is also to excavate the mud while it is frozen.

Optimizing the sluice and wash water characteristics will improve gold recovery. Each miner needs to understand the importance of these characteristics, and that various factors may offset each other with respect to gold recovery. For example, a lower water duty may offset higher viscosities, and reducing the time between cleanups may minimize riffle packing and its effects on gold recovery.

5.0 RECOMMENDATIONS FOR FUTURE STUDY

Numerous data gaps were identified during this study. Items wh require further investigation to expand the understanding of the use of recycle and other techniques in placer mining wastewater treatment are listed in the following two subsections. To some extent, these areas where further investigation is required should be viewed as limitations on the conclusions of this study. Recommendations are grouped as those pertaining to water quality (Section 5.1) and those pertaining to gold recovery (Section 5.2).

5.1 WATER QUALITY

(1) Water gain needs to be more thoroughly studied and understood. Potential methods for reducing water gain need to be investigated so that zero discharge might become feasible.

(2) Methods of contouring tailings and mined out areas should be examined to see if subsurface discharge of the final po

effluent for filtration is a viable approach to achieving zero surface discharge.

(3) The performance of settling ponds at very high influent suspended solids concentrations as might be encountered in a recycle situation or with alternative gold separation technology requires further study.

(4) The performance of coagulants and flocculants should be studied on low suspended solids concentrations as might be encountered in a final polishing operation on settling pond effluent. Considerable work on attainability of performance measured in the laboratory is required. Polymer mixing and feeding techniques in the field are perhaps the most critical factors affecting the economics of the use of flocculants.

(5) The performance of filtration as a final polishing step for setting pond effluent clarification could be one of the least expensive methods to reduce turbidity, and requires further field testing.

(6) Little is known about the performance of a multi-pond system versus one large pond in reducing the amount of sediment discharged. This topic should be investigated to allow prediction of their performance.

(7) More work on sediment particle sizes discharged from settling ponds is required. It is important to quantify the amount and size of fine material not settling in ponds.

(8) Because of the importance of knowing water flow balances within a mine system, improved techniques of flow measurement applicable to the mine site should be investigated.

(9) Additional research is required to determine if recycling requires the use of more water in the sluice as current data

suggest. This question has ramifications on the downstream water quality attainable by recycle.

(10) Much more work needs to be performed to understand the relationship between suspended solids concentrations and turbidity levels.

5.2 GOLD RECOVERY

(1) In order to conclusively determine the effect of recycling on fine gold recovery, a well-controlled test should be performed for an entire season under field conditions.

(2) The sluice and wash water characteristics cited above in Section 4.2 need to be assessed with respect to gold recovery to determine which characteristics are the most important to control to maximize gold recovery. Further testing is necessary to determine whether adequate prewashing will offset the detrimental effects of some of the characteristics.

(3) The compatibility of alternative gold separation devices with recycled water needs to be studied to determine if enhanced gold recovery and/or water quality results.

(4) If alternative gold separation technology is feasible in conjunction with recycle, then a greater understanding of the actual size distribution of gold in typical Alaska pay dirt (as opposed to the recovered size distribution) will be required to analyze the cost benefit of an alternative technology/recycle operation.

(5) Since viscosity has been implicated in gold loss, further work is required to document the range of viscosity levels found at placer mines. This is especially important at high rate recycle operations employing little or no makeup water, where

viscosity levels are expected to increase during a mining season.

(6) Development of a simple, inexpensive field method for measuring viscosity is critical. The study team used a Fann V-G Meter (Model 355A, Fann Instrument Corporation) successfully to measure viscosity, but this instrument is expensive and not entirely suitable for field use.

(7) Tailrace and settling pond sediments should be assessed to determine the presence of fine gold and the economic value if fine gold is present.

V. ENDING THE OPERATION (RECLAMATION)

GENERAL CONSIDERATIONS

(Adapted from USDOI-BLM, 1986a and USDOI-FWS, 1980a)

Plans should be prepared, and operations carried out with final reclamation in mind. They must adequately consider the intended methods and procedures for reclaiming the disturbed area, removal or leaving of permanent structures such as camps or river training dikes, and whether access is to be kept open after the site is reclaimed since this influences the required design life of the access road. Final reclamation requirements, as well as the required interim stabilization of areas during the operation, may affect how the operator strips overburden, locates settling ponds, diverts streams, locates roads, constructs buildings, stores fuel, selects operating and rehabilitation equipment and, in general, plans all phases of the operation. Reclamation of areas disturbed by casual use, notice or plan operations will occur annually or on completion of operations, as determined by the Authorized Officer, in conjunction with the operator. A schedule for reclamation will be a required part of all plans. It should be stressed, again, that BLM standards for reclamation are performance rather than design standards.

GOALS OF RECLAMATION

Fundamental goals of reclamation are to facilitate reestablishment and/or recovery of natural vegetation, to control thermal and water/wind erosion, and to provide for passage of fish and wildlife. In most cases, surface erosion on disturbed sites will be greatest in the period between grading/shaping and establishment of a protective vegetative cover. This means it is imperative that slope stabilization measures such as grading, contouring, terracing, etc. be applied as soon as possible after disturbing an area, so that reclamation is essentially concurrent with disturbance. These stabilization measures must be capable of providing rapid and effective erosion control benefits until a nurse or protective crop of fast-growing exotics or final native vegetation can be established. While having an operator do minimal grading, contouring and shaping and then applying large amounts of seed and fertilizer may be a common, effective practice elsewhere, in itself this is not generally acceptable reclamation in Alaska. With the short Alaskan growing season some sort of effective mechanical stabilization of disturbed lands is required to allow vegetation the time to recover.

During the course of many surface disturbing activities involving the processing of earth materials, inevitably some segregation by particle-size occurs - in fact many such activities, including placer mining, are predicated on effecting some sort of separation such as this. To varying degrees, this will be manifest in the resultant processed materials which are ultimately to be redistributed during reclamation of the disturbed area. This may or may not be a serious concern, in any given situation. An interesting, if perhaps somewhat extreme effect of this may occur in areas underlain by

permafrost. In the Fairbanks, Alaska area, some early placer mining operations on which little or no reclamation was attempted resulted in situations where coarser gravels remained segregated from silt/clay size materials, or were left under a capping of silt/clay/"soil" materials. This resulted in enhanced local drainage situations, with the further result that the previously underlying permafrost was thawed as well, to varying extents. This in turn resulted in the development of local ecosystems somewhat different from those originally present at these sites, prior to the mining activity. The desirability/acceptability of such a result might well be rather controversial, in any case. The chain of cause and effect relationships involved is illustrative, at least, of the complexities involved in attempting to manage surface disturbing activities and their attendant effects.

EXTENDED PERIODS OF NON-OPERATION

Because operations in Alaska are subject to many economic vicissitudes which may lead to abandonment, it is very important to protect the environment during prolonged periods of inactivity. Specific measures to be taken during any "temporary" work suspension should include, but should not be limited to:

Removal of all equipment, materials and stockpiles from the portion of the floodplain active during spring breakup or other predictable flood events.

INTERIM STABILIZATION

The operator must prevent and control on-site damage to surface resources during all operations. This should normally include the following, unless otherwise approved by the authorized officer:

a. Saving of all available topsoil (including the organic mat) for final respreading after reshaping the disturbed areas.

b. Stabilization of the saved topsoil, overburden and disturbed areas to prevent erosion, landslides or degradation of adjacent waters.

c. Isolation, removal or control of toxic materials.

d. As each part of an operation is completed, erosion control devices should be installed and the area should be reshaped, sloped, and graded immediately to blend with surrounding landscapes and to minimize ponding and/or erosion.

e. Provision for fish passage during and after operations.

f. Revegetation of all disturbed lands to prevent erosion prior to final reclamation.

g. All slopes or river banks cut or filled during access or other operations - related disturbance must be stabilized to prevent thermal, fluvial and/or wind erosion.

FINAL RECLAMATION

Reclamation of disturbed areas should be accomplished at the earliest feasible time, except to the extent necessary to preserve evidence of mineralization or for other acceptable compelling reasons. In addition to stabilization measures, final reclamation shall include the following, unless otherwise approved by the authorized officer.

a. Reshaping of all disturbed areas to an appropriate slope and shape consistent with the topography of the area, as feasible. The reclaimed area must be stable and have slope and shape that will prevent excessive erosion, and allow for passage of fish and wildlife.

b. The topsoil, organic overburden and vegetative slash and/or debris removed from the site and stored prior to mining should be respread over the site where reasonably practical. Mechanical stabilization and natural revegetation should be favored over artificial seeding and fertilizing.

c. Reestablishment of streams, including their approximate natural meanders and gradients.

d. Rehabilitation of fish and wildlife habitats.

e. All manmade debris and equipment must be removed from the site unless otherwise approved.

f. All access roads, culverts, low-water crossings and/or bridges installed by the operator should be removed (unless otherwise approved) and the areas reclaimed.

g. Settling ponds should be dewatered by pumping or slowly lowering dams/dikes. Trapped silt should be either (as approved):

   1. Stabilized and left in place, with due consideration for protection from flooding.

   2. Removed and broadcast with topsoil and other organic debris.

   3. Removed and taken to an approved disposal site.

   4. Seeded, if necessary, for stabilization.

RECLAMATION EQUIPMENT

Both the operator and BLM must always keep in mind what equipment will be readily available when it is time to reclaim. Any reclamation plan which requires unavailable equipment is essentially doomed. In Alaska, a miner generally will have a bulldozer or front loader, or both. This equipment, combined with various hand tools, may represent the entire reclamation equipment inventory, and plans must be made accordingly.

INFORMATION DESIRABLE FOR RECLAMATION OF FISH AND WILDLIFE HABITAT

If the plan calls for the disturbed site to be reclaimed as fish and wildlife habitat, the BLM and operator should develop the following types of information:

a. Site specific estimates of present and potential (after reclamation) hydraulic discharge, stages and valley cross-section.

b. Ground level sketches of the present physical and biological characteristics of the site and its environs.

c. After walking the entire site and the surrounding undisturbed area to develop an idea of the potential as fish and wildlife habitat, note the present habitat mixture, with a view towards possibly increasing habitat diversity through reclamation activities. Things to note include:

1. The type, amount and distribution of boulders, logs, and other velocity barriers and associated fishery habitat in all streams on or near site.

2. Stream bank vegetation, including whether banks are undercut or have overhanging vegetation, for all streams on or near site.

3. Submerged or emergent vegetation in waterways on or near site.

4. Water depth of all waterways on or near site.

5. Types of waterbird habitats offered by on or near site waterways.

6. Types of furbearer or game mammal habitats offered by on or near site surroundings.

7. Types of bird habitats offered by on or near site surroundings.

STREAM REHABILITATION

(Adapted from Rundquist et. al, 1986)

Stream rehabilitation should stabilize the active stream channel and provide it with proper configuration, size and profile to safely pass a two year flood event. If fish are present in the stream, rehabilitation should be planned to provide desirable fish habitat. The length of the stream reach being rehabilitated can be critical to overall success, and should approach as closely as possible the pre-disturbance length. If too short, the stream will tend to erode upstream and deposit downstream. If too long, it will tend to deposit upstream and erode downstream. In many cases, the bed and banks of rehabilitated streams will benefit from armouring of the bottom and banks with gravel, stones, riprap or other materials to insure bed and bank stability.

REHABILITATION OF A FLOODPLAIN

(Adapted from Rundquist, et al, 1986)

The objective is to return the floodplain to a condition that promotes rapid recovery of floodplain vegetation. Techniques to encourage this recovery include:

a. Creating a variety of plant microhabitats during the grading and shaping process, producing surface roughness to slow erosion and encourage revegetation.

b. Spreading topsoil or other suitable plant growth medium on top of coarse tailings. Sediment from settling ponds may provide an excellent growth medium in many instances.

c. Distributing woody debris over the graded floodplain to create microhabitats, and to provide seed.

SITE CONFIGURATION CAN EASE LATER RECLAMATION

(Adapted from USDOI-FWS, 1980a)

To ease later reclamation:

a. Avoid site configurations with long straight lines.

b. Avoid disturbing vegetation when constructing berms, dikes and other water control structures; if they do not need to be straight to work effectively, blend them with the surrounding terrain.

RECLAIMING A RIVERINE PIT EXCAVATION

(Adapted from USDOI-FWS, 1980a)

Disturbances, including excavations, in a floodplain can be reclaimed, and, if done properly, may actually increase local fish and wildlife habitat diversity if certain concepts are followed, including the following:

a. Excavations on the inactive floodplain, separated by vegetated buffers in the range of 150 - 300 feet from an active channel, generally are not in danger of influencing active channel hydraulics.

b. All excavations must be provided with a low water outlet at the downstream end of the pit to allow escape of any fish entering the pit during high water. A pit thus connected to an active channel may provide additional fish-rearing and overwintering habitat, provided that the pit provides a diversity of depths and a suitable average depth to minimize winter mortality.

c. Pits that are not and cannot practically be connected to the active channel may provide waterfowl and shorebird habitat if a diversity of depths is provided in the reclamation process.

d. Reclaimed pits are most beneficial to local fish and wildlife when they exhibit the following characteristics:

1. One acre or more in area.

2. Diverse shoreline configuration.

3. Diverse water depths.

4. Contain islands.

5. Contain an outlet connected to active channel.

Figures 19 and 20 illustrate these features.

FIGURE 19 . Example of a preferred shape and depth profile of pits in floodplain terraces and connected to the active channel (Taken from USDOI-FWS, 1980a).

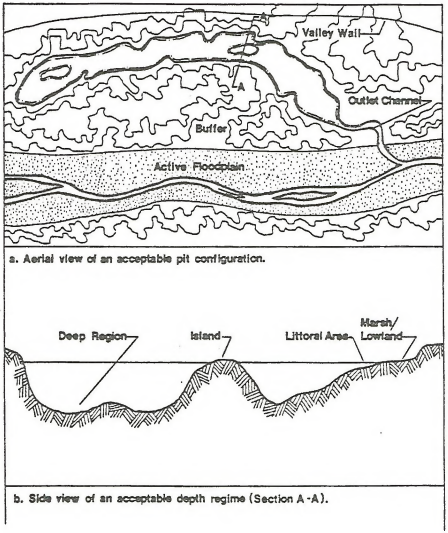
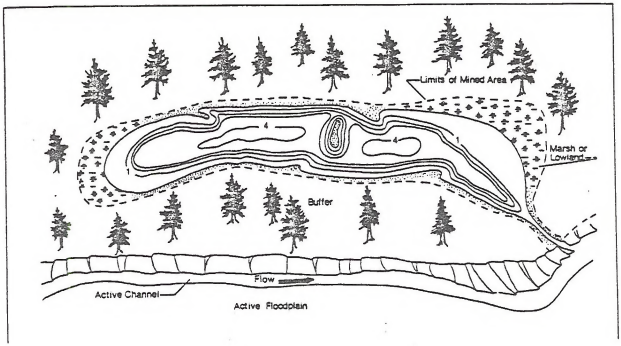


FIGURE 20 . Desired general configuration of a mine pit connected to an active channel (Taken from USDOI-FWS, 1980a).



SOME GUIDELINES FOR REVEGETATION IN ALASKA

(Adapted from Kubanis, 1982; see also Alaska Rural Development Council, 1983)

The primary goals for revegetation should be the ultimate reestablishment of native vegetation, and prevention of thermal and water/wind erosion. Reestablishment of native vegetation will provide erosion control, regenerate natural habitats and avoid the long term maintenance problems commonly associated with exotic plant cover which, of course, is less desirable, and expensive as well.

However, it must be appreciated that in many instances it may be most effective to utilize non-native species, at least on an interim basis. The sooner a disturbed site is revegetated the better, for reclamation, in terms of physical considerations of stabilization and erosion control. The rate of revegetation by native species may be too slow, in some cases, particularly on large areas of significant surface disturbance. The use of native species entails a source of propagula, either naturally or from some other source. There are few known commercial sources of native seeds for Alaska. The seeds of many native species have relatively low viability. On the other hand, there are some exotic species which seem to be sufficiently adaptable for many cases in Alaska. These include, but are not limited to, Bluegrass (Poa sp.), Fescues, Wheatgrass, Timothy, and Meadow Fox-Tail, all of which are readily available, have excellent characteristics for use in erosion control, and are generally replaced by native species eventually.

It should be stressed that efficient and effective revegetation requires site specific study by knowledgeable specialists, and that this is essential to ultimately satisfactory reclamation.

It should be emphasized that adequate site preparation is essential for native vegetation recovery, with inherent attendant erosion control and minimal maintenance requirements. In general:

a. Areas which have little or no erosion potential need not necessarily be seeded. These areas should still receive reapplication of surface materials, seedbed preparation and, if indicated by laboratory tests, light application of appropriate fertilizer to facilitate the reestablishment of native vegetation.

b. Areas with moderate erosion potential which appear to need some vegetative cover to assist in erosion control should receive reapplication of surface materials, seedbed preparation and be seeded at recommended levels, preferably with persistent, adapted native species and, as appropriate, light amounts of fertilizer.

c. In areas which have severe erosion potential even after grading, shaping and contouring, fertilizer and non-native grasses, such as annual rye grass, should be used as a nurse crop for invading native vegetation.

Site Treatment for all Disturbed Sites

1. Surface materials should be segregated and stockpiled for reapplication as an integral part of the mining process.

2. Final grading of both subsoil and topsoil should avoid producing a smooth surface, in order to allow the sub and topsoils to bond, and to provide enough roughness for native seed capture. Desireable surface roughness can be produced by scarifying, harrowing, chaining or other means.

3. The site should be tested for fertilizer and other needed amendments, and treated as early in the growing season as possible. Appropriate standard commercial fertilizer is generally acceptable.

4. All disturbed areas should be allowed to revegetate naturally (i.e. no seeding) except for those areas for which some type of fast-growing, exotic vegetation is necessary for erosion control.

5. Areas should be monitored to determine when additional maintenance treatments are necessary, such as fertilizer, watering, etc.

Treatment for Disturbed Sites with Significant Erosion Potential

1. As above, except for #4, as applicable.

2. Seeding of areas with moderate erosion potential preferably should consist of native species.

3. Areas of severe erosion potential needing dense, rapid vegetative growth should be appropriately fertilized and seeded at recommended rates with strips of annual rye, or other species with similar stabilization capability. Alternatively, a native seed mix containing no more than ten percent by weight of ryegrass spread evenly across the area of concern may be effective.

4. Any seeding should be done as early as possible in the growing season, or immediately before the first permanent snow cover in the fall (assuming this can be predicted with any confidence).

5. Mulching, if necessary, should be applied separately from fertilizer and seed to insure that seed is in contact with the soil.

6. Areas should be monitored to determine when additional maintenance treatments are necessary.

Other Revegetation Treatments and Guidelines

1. Do not try to revegetate predominantly gravel surfaces unless fines are available to blend in.

2. Sandy areas should be covered with topsoil or other growth - encouraging and anchoring medium, and seeded.

3. Whenever possible, strips or "islands" of natural vegetation should be left undisturbed within large mining areas to provide a seed source.

4. Large areas which must be planted to exotic, non-persistent grasses should be planted in narrow strips in order to leave gaps where native vegetation may invade.

5. Woody species should be investigated for planting along with other species for erosion control, wildlife habitat enhancement and provision for long-term, maintenance-free erosion control. Woody species plantings may be optimal in disturbed riparian habitats outside the annual floodplain, especially if riparian habitat is limiting to local wildlife.

6. Areas should be monitored to determine when additional maintenance treatments are necessary.

PREPARING THE SITE FOR REVEGETATION

(Adapted from USDA-FS, 1979c)

Preparation for revegetation should start with the preparation of the operations plan, or when the operator and BLM agree as to the optimal time for site rehabilitation and planting and, in general, what will be deemed as constituting success. Planting time in Alaska is usually in the spring and very early summer, but may vary depending on what time of the year surface disturbing activities conclude. The area of concern must receive any needed preliminary grading and shaping prior to topsoil placement. The following operations are important to provide an environment that will be within the tolerances of the plants:

a. Rip, harrow or scarify the subsoil to eliminate the compaction stemming from subsoil placement, grading and shaping. (During revegetation on the pipeline [TAPS], a contour harrow consisting of a large wire mesh with heavy wires protruding downward was towed over the surface both before and after seeding to increase germination success.) This step may not be essential, if good quality topsoil, or other loose material, in sufficient amount, is available for spreading.

b. Spread topsoil over subsoil.

c. Rip, harrow, or scarify topsoil to eliminate the compaction stemming from topsoil placement.

d. Stabilize area to prevent erosion and await natural revegetation.

OR

d. Spread and blend in fertilizer and/or other soil treatments if required by the AO, after laboratory testing spoil and topsoil to determine proper amounts.

e. Plant (drilling is the best method of seed planting but in most cases, some type of broadcasting will be used) if required by the AO.

f. Stabilize area to prevent erosion.

SELECTING SPECIES FOR REVEGETATION

(Adapted from USDA-FS, 1979c)

If BLM approves or requires initial revegetation other than natural revegetation, the proper species mix must be selected. Not all species are adapted to all sites or uses, and a number of factors affect adaptability. The ability of the selected species to complete its life cycle and replace itself in succeeding generations is the goal of this species selection. Here are a few things to keep in mind in making a selection:

a. "Nurse" crops or "companion" crops, which are usually unadapted annual species, may have to be planted either before or with the permanent species mix, in order to temporarily stabilize the site. However, the nurse crop must be selected carefully, as some may persist long enough to provide excessive competition with desired permanent species.

b. BLM directives and State of Alaska regulations should be consulted concerning unwanted "weed" species before formulating the species mix.

c. Each species in the permanent mix must be investigated to insure compatibility of its growth form, stress tolerance, mineral nutrition requirements and reproduction characteristics with other species in the mix.

d. Costs and availability of each species should be considered before determining the final mixture.

e. The amount of maintenance each species in a mix requires after initial establishment is extremely important.

f. Each species in the mix, and the mix as a whole, must be adaptable to:

   1. Soil characteristics at the site, including pH, fertility, texture, depth, permeability, presence of toxic materials and water retention capacity.

2. Precipitation at the site, including both total amount and seasonal distribution.

3. Local temperatures, including species hardiness over the annual cycle of highs and lows.

4. Elevation of the site.

5. Slope of site, which influences soil stability and the amount of sun received.

6. Aspect or exposure of the site, which affects day length, solar radiation loads and length of growing season.

7. Wind velocities blowing across the site.

8. Other factors such as reaction to fire, browsing/grazing, pest resistance, etc.

DETERMINING WHETHER TO USE SEEDS OR SEEDLINGS

(Adapted from USDA-FS, 1979c)

Seeds are usually the least expensive plant materials for revegetation, if they can be properly applied when sufficient moisture for germination is expected. They can be used whenever site erosion is not a major problem, and when the proper mix for the site can be economically obtained. Seedlings should be used when site conditions are harsh and where a faster developing ground cover is important enough to offset the greater cost. Seedlings can be obtained in many different forms. Choice of the form, such as container-grown stock, bare-root stock, cuttings, rhizomes, sprigs, wildings or plugs, again depends on relative cost versus desired level of revegetation success.

WHEN TO USE SEED AND FERTILIZER

Given that the goal of reclamation is to enhance the eventual recovery of natural, native, indigenous plant species and to prevent the disturbed area from eroding and polluting streams in the future, application of seed and fertilizer alone will not provide effective reclamation.

Site-specific applications of exotic nurse crop seed and fertilizer where tests and/or Alaskan experience have shown it to be needed, where it is applied during the proper season and repeated as necessary may indeed enhance native plant recovery, especially on sites where no organic materials or topsoils are available for respreading, and where a mineral soil was used as a seedbed. However, no amount of seed and fertilizer will allow establishment of permanent vegetation on bare rock or gravel without any topsoil or organic cover. It should also be emphasized that application of exotic seed and fertilizer may allow exotic species to outcompete native species, and prevent or inhibit native plant recovery. Unless there is refertilization each year, most exotic species will die after their rapid growth has used up not only the commercial fertilizer but all of the naturally available nutrients on the site normally available to native plant recovery. In some cases, it is best not to

apply any exotic seed and/or commercial fertilizer. Application of exotic seed and fertilizer to improperly prepared sites or during the wrong season will do nothing to help native plant recovery. If the site has not been properly prepared the seed and fertilizer will probably be washed off with the first rains. If the seed and fertilizer is applied in fall or winter, it may often be carried away with breakup, although in some instances seed may work its way into the ground through frost cracks and become covered up during breakup.

THE POST-OPERATION MONITORING PROGRAM

BLM and the operator should both be concerned that site reclamation will last through the years and return the site to some useful purpose. If the site was artificially revegetated, it should be refertilized and replanted as necessary until an erosion resistant, self-sustaining growth of vegetation has been established. This does not mean that every square inch of a site must support vegetation. If the site is stable (erosion resistant) with only 10% cover, the site can, in general, be considered to have been successfully reclaimed. BLM should continue to monitor the site following initial reclamation, in order to have any shortcomings corrected, until reclamation is deemed to be complete. This post-operations monitoring is essential to successful reclamation. Not all reclamation attempts will be equally "successful". There should be as clear and unambiguous an understanding as possible between the operator and BLM as to what will constitute "successful, complete" reclamation in each instance, on a case-by-case basis. This is imperative.

APPENDIX V.

ENDING THE OPERATION (RECLAMATION)

Included in this Appendix are selected materials which should be of particular interest to the general subject of "reclamation".

INFORMATION SOURCES

1. United States Department of Agriculture, Cooperative Extension Service:

   a. University of Alaska
      2221 East Northern Lights Blvd., Suite 240
      Anchorage, AK 99508-4143
      Phone: (907) 279--5582

   b. District Office
      1514 South Cushman, Room 303
      Fairbanks, AK 99701-6285
      Phone: (907) 452-1548

   c. University of Alaska
      Fairbanks, AK 99775-5200
      Phone: (907) 474-7246

2. State of Alaska, Department of Natural Resources
   Division of Agriculture/Plant Materials Center
   Star Route B, Box 7440,
   Palmer, AK 99645
   Phone: (907) 745-4469

BUREAU OF LAND MANAGEMENT

WATERSHED REHABILITATION

TRAINING COURSE

Colorado State University
Fort Collins, Colorado

BASIC OUTLINE FOR REHABILITATION OF MINED LANDS

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BASIC OUTLINE FOR REHABILITATION OF MINED LANDS

A CHECKLIST

Paul E. Packer, Consulting Forester

A. Characteristics of Drastically Disturbed Lands

1. Climate and weather characteristics
   a. Precipitation
      (1) amount
      (2) form
      (3) seasonal distribution
   b. Temperature and solar radiation
      (1) length of growing season
      (2) potential evapotranspiration
      (3) freeze/thaw frequencies

2. Spoil characteristics
   a. Physical
      (1) physiography
         (a) aspect
         (b) slope steepness
         (c) slope length
      (2) spoil properties
         (a) field determined
            i. horizon thickness
            ii. color
            iii. texture
            iv. structure
            v. consistency
            vi. hardness
         (b) laboratory determined
            i. texture
            ii. dispersion
            iii. weatherability
            iv. porosity
            v. water retention capacity
            vi. saturation percentage
            vii. hydraulic conductivity

   b. Chemical
      (1) fertility (nutrient levels)
         (a) nitrogen
         (b) phosphorus
         (c) potassium
         (d) calcium
         (e) magnesium
         (f) sodium
         (g) trace elements
         (h) cation exchange capacity

(2) acidity
  (a) pH
  (b) metalic sulfides
  (c) acid-base equilibrium
  (d) lime requirement
(3) salinity-sodicity
  (a) pH
  (b) soluble salts
  (c) water soluble ions
  (d) sodium adsorption ratio (SAR)
  (e) exchangeable sodium percentage (ESP)
  (f) water soluble anions
  (g) gypsum
(4) toxicity
  (a) boron
  (b) molybdenum
  (c) selenium
  (d) radioactive components

3. Hydrologic characteristics
  a. Infiltration capacity
  b. Hydraulic conductivity
  c. Storage capacity
  d. Surface water drainage
  e. Internal water drainage

4. Mass stability characteristics
  a. Spoil dump orientation
  b. Spoil dump configuration
  c. Texture of materials
  d. Placement of spoils (method)
  e. Compaction
  f. Surface water diversion options
  g. Internal water diversion options

5. Biological characteristics
  a. Vegetation
    (1) species on mined areas
    (2) species on similar unmined areas
      (a) adaptability
      (b) growth form
      (c) drought resistance
      (d) stress tolerance
      (e) nutritional requirements
      (f) reproductive methods and potential
      (g) competitive capabilities
      (h) bio-mass production characteristics
        i. above ground
        ii. surface litter
        iii. root systems

  b. Other organisms
    (1) macro-organisms

(a) above-surface dwellers
(b) surface dwellers
(c) subsurface dwellers
(2) micro-organisms
(a) bacteria
(b) fungi

6. Resource Damage Effects of Surface Mining
   a. Spoil surface erosion (soil loss and sedimentation)
      (1) sheet
      (2) gully
   b. Mass instability
      (1) surface
      (2) internal
   c. Acidity
      (1) plant growth reduction
      (2) acid soil and acid water production
   d. Alkalinity-Sodicity
      (1) plant growth reduction
      (2) alkaline-saline soil and water production
   e. Toxicity
      (1) plant growth reduction
      (2) toxic plants and toxic soil and water production
   f. Compounding interactions of spoil chemistry and hydrologic behavior
   g. Secondary effects
      (1) wildlife-livestock poisoning
      (2) fish poisoning-fish habitat damage

B. Principles of Rehabilitation
   1. Order of events for successful rehabilitation

      a. Design spoil dumps
         (1) survey of alternative dump sites
         (2) dimensions and economic appraisal of alternative sites
         (3) geologic appraisal
         (4) foundation and materials investigation
         (5) analysis of surface water diversion requirements
         (6) analysis of internal drainage requirements
         (7) develop specifications for materials placement
         (8) verify materials properties and placement procedures during dump construction

      b. Analyze soil and overburden
         (1) identification of topsoil (A horizon)
         (2) sampling by horizons (several methods)
         (3) characteristics by horizons
            (a) physical
            (b) chemical

(c) toxic
(d) erosive
i. water erosion (Universal Soil Loss Equation)
ii. wind erosion (SCS Wind Erodibility Groups)

c. Select storage areas for mined materials
(1) temporary storage
(a) topsoil for resurfacing
(b) overburden to be used as backfill
(c) ore awaiting shipment
(2) permanent storage
(a) overburden other than that for backfill
(b) tailings ponds (mill tailings, etc)
(3) physical and chemical reaction of spoils
(4) selective handling requirements for toxic spoils

d. Handle mined materials
(1) confirm location and extent of inhibitory zones
(a) dilution (if inhibitory zone < 15% of overburden)
i. scatter spoiling (usually best)
ii. dump spoiling
(b) selective handling
i. isolate from acquiters
ii. isolate from region of plant root growth
a. capillary barrier
b. bury deeply
(2) topsoil handling
(a) immediate use (best)
(b) stockpile

e. Treat spoil problems
(1) physical problems
(a) improve spoil texture, structure, organic matter
i. mix spoils
ii. mechanical surface manipulation
iii. mulch
(2) chemical problems
(a) acidic spoils
i. limit exposure of surface spoils
ii. lime
iii. topsoil
iv. select acid tolerant plants for revegetation
(b) alkaline-saline spoils
i. leach
ii. mulch

iii. chemical amendments
a. soluble calcium salts (gypsum)
b. acids or acid-formers (sulfates)
(c) toxic spoils
i. control pH to prevent uptake of toxic metals
ii. select metal-tolerant plants for revegetation
(3) biological problems
(a) macro-organic problems
i. suitability of spoils for domestic animal and wildlife use
ii. deterioration of site by improper or over use
(b) micro-organic problems
i. reestablish micro-organisms in spoils
a. replace topsoil
b. correct spoils for acid, salt, toxicity problems
c. add nutrients (fertilize)
(i) carbon
(ii) phosphorus
(iii) nitrogen
d. inoculation
(1) nitrogen-fixing algae and/or bacteria
(2) mulch with surface material from undisturbed sites

f. Surface the spoils
(1) erosion control
(a) use flatter slopes
(b) use shorter slopes
(c) contour furrow
(d) pit and gouge
(e) build sediment basins
(f) topsoil spoils
(g) revegetate quickly
(2) abate toxic-element and salt migration
(a) capillary barriers

g. Revegetate the spoils

2. Revegetation principles

a. Species selection
(1) native vs. introduced species
(2) adapted species
(3) legal requirements
(4) rehabilitation objective (function the pla are to serve)
(5) compatibility of species
(6) plant materials availability, source, and

suitability
(7) need for maintenance after planting
(8) cost of plant materials

b. Plant material options
(1) seeds
(2) container-grown planting stock
(3) bare-root stock
(4) cuttings, rhizomes, sprigs
(5) wildings, plugs

c. Site preparation for planting (tillage)
(1) primary tillage
(a) ripping
(b) disking
(c) chisel plowing
(d) stubble mulch tilling
(2) secondary tillage
(a) disk harrowing
(b) roller harrowing and packing
(c) spring-tooth harrowing
(3) timing of tillage operations
(a) immmediately prior to planting (best)
(b) sequence of site preparation operations
i. rip
ii. disk or harrow
iii. fertilize
iv. harrow in fertilizer
v. plant

d. Other site preparation for planting (non-tillage)
(1) acid spoil treatment
(2) alkaline-saline spoil treatment
(3) toxic spoil treatment

e. Planting methods
(1) best planting time
(2) planting seeds
(a) drilling (best)
i. seeder cultipacker (one of the best)
ii. rangeland drill (for rough terrain)
iii. steep slope seeder
iv. Nesbitt single or double disk drill (gentle slopes)
v. Noble drill (compacted, rocky, gravelly soils)
(b) broadcasting
i. centrifugal seeder
ii. field distributor
iii. fan seeder (cyclone seeder)
iv. hydroseeder
v. aerial seeding
(3) planting other materials
(a) container grown stock

(b) bare-root stock
(c) cuttings
(d) wildings and plugs
(e) trees
(f) mixed seeding

f. Cultural treatments
(1) irrigation
(a) sprinkler type
(b) drip type
(2) mulches
(a) water erosion control
(b) wind erosion control
(c) water conservation
(d) surface temperature control
(e) weed control
(f) problems with mulches
i. immobilization (tying up) of nitrogen, phosphorus, and sulfur
ii. germination inhibition
iii. attraction of undesirable organisms
(3) fertilizers
(a) permit plant establishment
(b) speed-up plant growth
(c) maintain plant productivity
(d) initiate nutrient eyeling
(e) nutrients of importance and most often lacking
i. nitrogen
ii. phosphorus
iii. organic carbon
iv. potassium
v. calcium
vi. magnesium
vii. sulfur
(f) maintenance refertilization
i. nitrogen - every 2 or 3 years
ii. phosphorus - once to start P cycling
(g) amounts
i. requires heavy fertilizing (200-800 lbs/acre)
ii. smaller amounts of micro nutrients
a. boron
b. manganese
c. copper
d. zinc
e. molybdenum
f. chlorine

(4) water harvesting
(a) in areas of 15 inches annual precipitation
(b) $\frac{\text{water collection area}}{\text{plant growth area}} = \frac{3}{1}$ to $\frac{30}{1}$
(c) mechanical-chemical sealing materials

(5) nurse crops
    (a) temporary (annual) cover
    (b) protects topsoil against
        (1) water erosion
        (2) wind erosion
    (c) provides improved site conditions for species used in revegetation
(6) cultivation
    (a) weed control
    (b) breaks surface crust
    (c) improves infiltration
    (d) promotes spoil aeration
    (e) increases root systems

3. Post-revegetation management and monitoring

a. Protect spoils against animal damage
    (1) fencing
    (2) herding
    (3) repellants and/or poisoning
    (4) salt distribution
    (5) water source selection
    (6) control time of grazing use
    (7) encourage predators

b. Protect spoils against weeds
    (1) mowing
    (2) herbicides
    (3) defoliants
    (4) dessicants

c. Protect spoils against insects
    (1) liquid spray insecticides
    (2) dusting insecticides

d. Monitor rehabilitated areas
    (1) plant succession
    (2) productivity
    (3) utilization
    (4) refertilization needs
    (5) special emphasis areas
        i. roads
        ii. harsh sites
        iii. reclamation failures
    (6) water pollution
    (7) erosion

Best Management Practices for Placer Mining Technical Report

by
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TABLE OF CONTENTS

Page

ACKNOWLEDGEMENTS

1.0 INTRODUCTION 1
1.1 OBJECTIVE 1
1.2 SCOPE 2
1.3 REPORT ORGANIZATION 3

MINING PLAN

2.0 MINING PLAN 9
2.1 PRE-MINING SITE CONDITIONS 11
2.2 SITE PLANNING AND DESIGN 13
2.2.1 General 13
2.2.2 Site Preparation 14
2.2.3 Site Operation 16
2.2.4 Site Closure and Rehabilitation 17

NONPOINT-SOURCE POLLUTION CONTROL

3.0 INTRODUCTION TO NONPOINT-SOURCE POLLUTION CONTROL 23
3.1 OBJECTIVE AND SCOPE 23
3.2 SUMMARY 24

4.0 DRAINAGE CONTROL 31
4.1 OBJECTIVES AND SCOPE 31
4.2 SETTLING PONDS 32
4.2.1 Settling-Pond Siting 33
4.2.2 Settling-Pond Design 35
4.2.3 Settling-Pond Construction 36
4.2.4 Settling-Pond Operation 36
4.2.5 Settling-Pond Rehabilitation 37
4.3 STREAM CHANNEL DIVERSION 38
4.3.1 Diversion-Channel Siting 38
4.3.2 Diversion-Channel Design 39
4.3.3 Diversion-Channel Construction 48
4.3.4 Diversion-Channel Rehabilitation 50
4.4 BEDROCK DRAINS 50
4.5 OVERLAND FLOW 53

5.0 SITE GRADING 59
5.1 OBJECTIVES AND SCOPE 59
5.2 PROGRESSIVE SITE GRADING 59

6.0 STOCKPILE PLACEMENT AND PROTECTION 65
6.1 OBJECTIVES AND SCOPE 65
6.2 STOCKPILING 65

SITE REHABILITATION

7.0 INTRODUCTION TO SITE REHABILITATION 75
7.1 OBJECTIVE AND SCOPE 75
7.2 SUMMARY 75

TABLE OF CONTENTS
(Continued)

Page

8.0 STREAM REHABILITATION..... 83
8.1 OBJECTIVES AND SCOPE..... 83
8.2 DESIGN FLOWS..... 84
8.2.1 Risk Assessment and Recurrence-Interval Selection..... 85
8.2.2 Design Flow Computation..... 88
8.3 STREAM PATTERN AND PLACEMENT..... 92
8.3.1 Definitions..... 92
8.3.2 Selection of Stream Pattern..... 94
8.3.3 Stream Length.....100
8.3.4 Placement of Stream Pattern.....100
8.3.5 Stream Bed Elevation.....102
8.4 HYDRAULIC DESIGN.....105
8.4.1 Meandering-Stream Design.....105
8.4.2 Mountain-Stream Design.....114
8.4.3 Braided-Stream Design.....126
8.5 CHANNEL STABILITY.....128
8.5.1 Bed Stability.....128
8.5.2 Bank Stability.....131
8.5.3 Riprap Design.....131

9.0 FISH HABITAT REHABILITATION.....139
9.1 OBJECTIVES AND SCOPE.....139
9.2 FISH HABITAT COMPONENTS.....142
9.3 HABITAT REQUIREMENTS.....142
9.3.1 Anadromous Fish.....144
9.3.2 Resident Fish.....151
9.4 HABITAT DESIGN FOR FISH STREAMS.....154
9.4.1 Meandering Streams.....157
9.4.2 Mountain Streams.....166
9.4.3 Braided Streams.....170

10.0 FLOODPLAIN REHABILITATION.....175
10.1 OBJECTIVES AND SCOPE.....175
10.2 SITE GRADING.....176
10.2.1 Riparian Zone.....177
10.2.2 Inactive Floodplain.....183
10.2.3 Valley Terrace.....188
10.2.4 Valley Bench.....188
10.3 STOCKPILE DISPERSEMENT.....190
10.4 REVEGETATION.....197

APPENDIX A REFERENCES CITED.....203

APPENDIX B GLOSSARY.....217

APPENDIX C MAPS OF MEAN ANNUAL PRECIPITATION.....227

A Revegetative Guide for Alaska

Alaska Rural Development Council

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Table of Contents

I. Introduction 1

II. Culture and Management for Establishment of Vegetation 2

A. Establishment of Grasses and Other Herbaceous Plants 2

1. Soil 2
2. Seedbed Preparation 2
3. Seed Specifications 2
4. Time of Seeding 3
5. Seeding Methods 3
   a. Drill 3
   b. Hydroseed 5
   c. Broadcast 5
   d. Sprigging 6
6. Fertilization and Liming 6
   a. Fertilization 6
   b. Liming 7
7. Maintenance 7
8. Mulching 7
9. Companion/Nurse/Cover Crop Seedlings 7

B. Establishment of Woody Plants 8

1. Soils 8
2. Collection and Handling of Propagation Material 9
   a. Seed 9
   b. Seedlings 10
   c. Cuttings 10
3. Seeding 10
   a. Site Preparation 10
   b. Time 10
   c. Methods 10
   d. Rate 10
4. Planting 11
   a. Site Preparation 11
   b. Time 11
   c. Methods 11
   d. Rate 11
   e. Maintenance 11
5. Fertilization 11
   a. Mineral Soil vs. Organic Soil 11
   b. Interplanting 12
   c. Fertilization Rates 12

III. Soil and Site Groups 13

Group 1: Soils and Sites with Few or No Limitations 14

Group 2: Soils and Sites with Moderate Limitations Due to Low Water Holding Capacity 15
Group 3: Soils and Sites with Severe Limitations Due to Very Low Water Holding Capacity or Steep Slopes 16
Group 4: Soils and Sites with Moderate Limitations Due to Excess Moisture 17
Group 5: Soils and Sites with Severe Limitations Due to Excess Moisture 18
Group 6: Soils and Sites Consisting of Wet Peat Materials 19

MAP—Alaska's Geographical Areas 20

IV. Grasses and Other Herbaceous Plant Seeding Recommendations 21

Introduction 21

Arctic and Alpine Area, Groups 1 & 2 22
Arctic and Alpine Area, Group 3 23
Arctic and Alpine Area, Group 4 24
Arctic and Alpine Area, Group 5 25
Arctic and Alpine Area, Group 6 25
Cook Inlet—Susitna Area, Groups 1 & 2 26
Cook Inlet—Susitna Area, Group 3 27
Cook Inlet—Susitna Area, Group 4 28
Cook Inlet—Susitna Area, Group 5 29
Cook Inlet—Susitna Area, Group 6 29
Interior Area, Group 1 30
Interior Area, Group 2 31
Interior Area, Group 3 32
Interior Area, Group 4 33
Interior Area, Group 5 34
Interior Area, Group 6 35
Southeast Area, Groups 1, 2 & 3 36
Southeast Area, Group 4 37
Southeast Area, Group 5 & 6 38
Southwest Area, Groups 1 & 2 39
Southwest Area, Group 3 40
Southwest Area, Group 4 41
Southwest Area, Group 5 42
Southwest Area, Group 6 43
Western Area, Group 1 & 2 44
Western Area, Group 3 45
Western Area, Group 4 & 5 46
Western Area, Group 6 47

V. Lawn and Turf Seeding 49

A. Introduction 49

B. Seeding 49

1. Seed 49
2. Seedbed Fertilization 49

C. Cultural Practices After Establishment 49

1. Watering 49
2. Fertilization 49
3. Mowing 50

D. Athletic Turfs 50

1. Reseeding 50
2. Fertilization 50

VI. Woody Plant Recommendations 51

Introduction 51

Arctic & Alpine Area Groundcovers 53
Arctic & Alpine Area Intermediate Shrubs 54
Arctic & Alpine Area Trees and Tall Shrubs 54

Cook Inlet—Susitna Area Groundcovers 55
Cook Inlet—Susitna Area Intermediate Shrubs 56
Cook Inlet—Susitna Area Trees and Tall Shrubs 57

Interior Area Groundcovers 58
Interior Area Intermediate Shrubs 59
Interior Area Trees and Tall Shrubs 60

Southeast Area Groundcovers 61
Southeast Area Intermediate Shrubs 62
Southeast Area Trees and Tall Shrubs 63

Southwest Area Groundcovers 64
Southwest Area Intermediate Shrubs 65
Southwest Area Trees and Tall Shrubs 66

Western Area Groundcovers 67
Western Area Intermediate Shrubs 68
Western Area Trees and Tall Shrubs 69

Appendices 70

A. Land Capability Classification 71

B. Common and Scientific Names of Grasses and Legumes 72

C. Plant Characteristics 73

1. Grasses 73
2. Legumes 76
3. Woody Plants 77

a. Groundcovers 77
b. Intermediate Shrubs 79
c. Trees and Tall Shrubs 81

D. Commercially Available Groundcovers 83

1. Herbaceous Groundcovers 83
2. Woody Groundcovers 84

E. Drill Calibration 85

1. Table 1. Calibration Data for Various Row Spacings 85
2. Table 2. Conversion Factors to Determine Bulk Seed Needed to Obtain One Pound of Pure Live Seed 86

F. Sources for Technical and On-Site Assistance 87

G. Reference Sources 88

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Appendix G

Reference Sources

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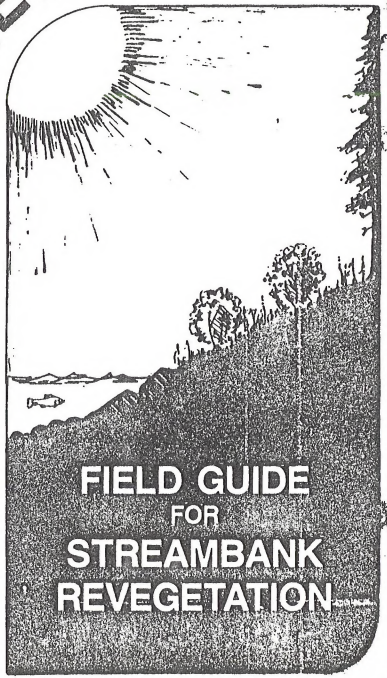
STREAMBANK REVEGETATION

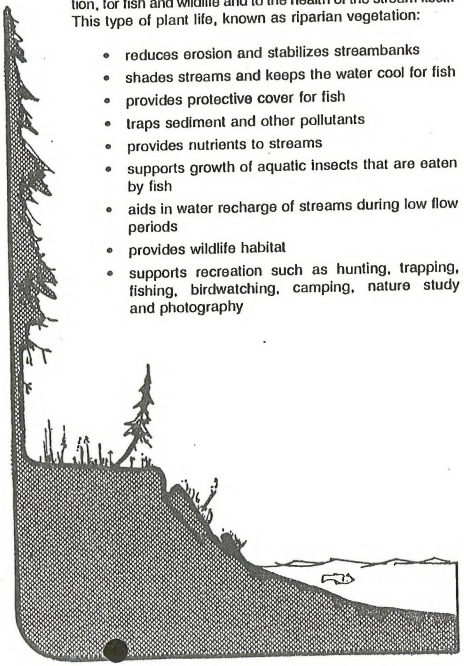


FIELD GUIDE FOR STREAMBANK REVEGETATION

WHY REVEGETATE?

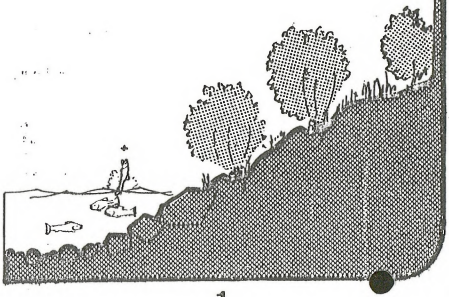
Vegetation found along streambanks is important for recreation, for fish and wildlife and to the health of the stream itself. This type of plant life, known as riparian vegetation:

- reduces erosion and stabilizes streambanks
- shades streams and keeps the water cool for fish
- provides protective cover for fish
- traps sediment and other pollutants
- provides nutrients to streams
- supports growth of aquatic insects that are eaten by fish
- aids in water recharge of streams during low flow periods
- provides wildlife habitat
- supports recreation such as hunting, trapping, fishing, birdwatching, camping, nature study and photography



Riparian vegetation is different from upland vegetation because plants that grow next to a stream must be able to endure wet soil conditions and periodic flooding. Willows, poplars, cottonwoods and alder are common woody riparian plants.

Whenever disturbed, riparian vegetation should be reestablished to prevent erosion and property damage and to restore the stream to a more productive condition. This brochure describes how to revegetate streambanks with woody plants. All of the techniques rely on the remarkable ability of certain woody plants to sprout both roots and shoots from stem pieces cut during dormancy (winter). This brochure was developed for Southcentral Alaska and while the techniques can be used anywhere, recommendations for the particular plant species to use or for timing of planting may not be appropriate for other areas of the state. Information on the best plant species to use or timing for other areas of the state can be obtained by contacting the agencies listed at the end of this brochure.

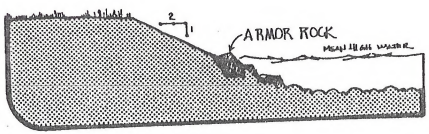


PLANNING:

Before you actually start planting, it is important to plan your project. The following points should be considered when preparing a streambank restoration plan.

1. **Examine the site and identify problem erosion areas.** If the streambank is eroding, it must be physically stabilized before revegetation can be undertaken successfully. Failure to stabilize the bank may result in your plants being washed away. Severe erosion problems can often be corrected by:

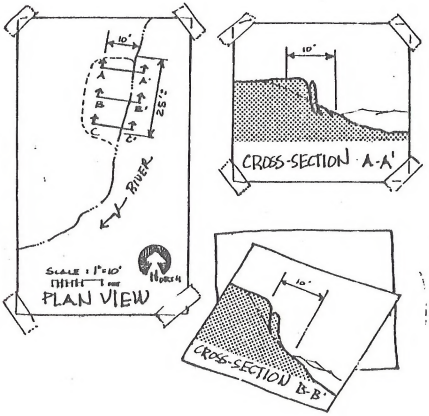
   - reducing the slope of the streambank to at least 2:1 (horizontal to vertical distance)



   - diverting surface runoff or channelizing it into erosion resistant ditches
   - armoring the eroding portions of the streambank with rock or gabions.

   You should check with the Habitat Division of the Department of Fish and Game, the Regulatory Branch of the Corps of Engineers and the local government before modifying any streambanks because permits may be required. These agencies can also make recommendations for successful streambank stabilization, and they can assist you in designing your project.

2. **Measure and sketch the area to be revegetated.** The length and width of the area to be revegetated should be measured and then drawn to scale. A plan (birds-eye) view and a cross-sectional view that shows the steepness of the slope should be sketched. These sketches will help you to visualize the project and help you determine how many plants you need.

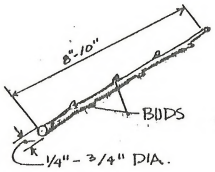


3. **Select the revegetation technique best suited to the site.** There are three techniques for revegetation with woody plants that have proven successful in Southcentral Alaska:

   - dormant cuttings
   - bundles
   - rooted cuttings

All of these techniques rely on cuttings of stems taken from plants in the wild during the late winter, and they all require proper storage and care of the cuttings between the time of collection and the time of planting. For dormant and rooted cuttings, short pieces of the stems are cut from wild plants. For bundling, much longer pieces are cut. Cuttings for dormant plants and bundles are simply placed in cold storage between collection and planting, whereas rooted cuttings must be planted in soil and cared for in greenhouse conditions (a warm place with light). They may be used alone or in combination. These techniques are described in greater detail below.

DORMANT CUTTINGS



Dormant cuttings: Dormant cuttings are cuttings taken in the early spring before buds have opened. They should be 8-10 inches long and ¼ to ¾ of an inch in diameter, with visible buds. Cuttings must be kept frozen or refrigerated until the site is ready to plant.

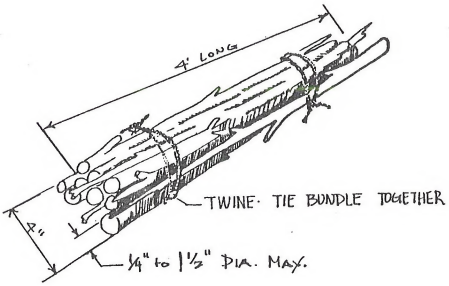
Advantages:

- easy to prepare and plant
- low cost

Disadvantages:

- must be kept frozen or refrigerated until planted
- while in storage, must not be allowed to dry out or become too moist
- requires more material to be planted than when using rooted cuttings
- relatively moist sites required, particularly during the early stages of establishment
- can be planted only from early spring through July 1

BUNDLES



Bundles: Bundles are dormant branches ¼ to ½ of an inch in diameter approximately 4 feet long tied together in bunches about 4 inches in diameter.

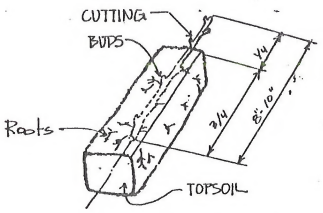
Advantages:

- provide cover quickly
- effective in reducing soil erosion
- the bundle itself provides physical protection

Disadvantages:

- must be kept frozen or refrigerated until planted
- while in storage, must not be allowed to dry out or become too moist
- requires a great amount of plant material
- can be planted only from early spring through July 1

ROOTED CUTTINGS



Rooted cuttings: These are dormant cuttings that have been rooted in a controlled environment before being planted in the field.

Advantages:

- allows the healthiest cuttings to be selected for planting
- older or more developed plants which tend to have a higher survival rate can be used
- become better established at drier sites than bundles or dormant cuttings

Disadvantages:

- more costly and time consuming than dormant cuttings
- plants must be grown in a greenhouse or other indoor conditions
- more care is needed when transplanting rooted cuttings

REVEGETATION PROCESS

1. **Find an area with appropriate plant species.** Ideally, you will want to select the species that grow at your specific site because these plants will be the best adapted to conditions at your site. You will also want to collect your plant material from a site near your project. Since it is easier to identify species when leaves are present, you will need to identify a collecting site in the summer, before you expect to collect plant material.

   See *Alaska Trees and Shrubs* by Leslie A. Viereck and Elbert L. Little, Jr. (1972, U.S.D.A. Agriculture Handbook No. 410, 265pp.) for an excellent summer and winter key for identification of willows and poplar. This book is available in your local library.

   Woody plants that root readily and are suitable for streambank revegetation include the following:

   - Balsam poplar - *Populus balsamifera*
   - Black cottonwood - *Populus trichocarpa*
   - Feltleaf willow - *Salix alaxensis*
   - Pacific willow - *Salix lasiandra*
   - Barclay willow - *Salix barclayi*
   - Scouler willow - *Salix scouleriana*

   Species that are unsuitable and will not root from stem cuttings include:

   - Alder - *Alnus* sp.
   - Birch - *Betula* sp.
   - Quaking aspen - *Populus tremuloides*

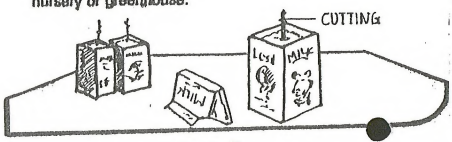
2. **Equipment needed.** For collecting the cuttings, you will need large plastic bags, twine, clippers, pruners, or a bow saw, and a knife. For planting, you will need a shovel or a pick, 18-inch wooden stakes and a mallet for bundles.

3. **Collection and storage.** For dormant or rooted cuttings, select branches of ¼ to ¾ of an inch in diameter with buds. Cut the branches into 8-to-10-inch lengths.

   For bundles, select branches of ¼ to ½ of an inch in diameter, both with and without buds. Bundles should be about 4 feet long. Group the branches together to form a bundle approximately 4 inches in diameter. Tie the bundle together in two to three places with twine.

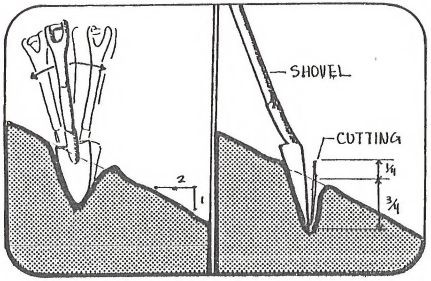
   Place cuttings and bundles in plastic and put in cold storage until ready to use. Cuttings can be kept frozen or refrigerated. They must not be allowed to dry out, or neither should they be kept too moist. If cold storage facilities are not available, cuttings can be stored in a snowbank along the north side of a building or some other location that will remain cold until planting.

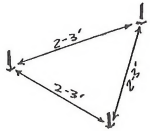
4. **Rooting cuttings.** To root cuttings at home, place the dormant cuttings in containers filled with loose potting soil or sand, or some other rooting medium so that one-half to three-fourths of the cutting is covered by the soil. Keep the cuttings in moist soil, at 55° to 65° F, and in filtered light until leaves begin to appear. When leaves appear, put the cuttings in a sunny window or under grow lights. It takes six to eight weeks to produce a vigorous rooted cutting. If you need additional information or supplies you should contact a local commercial nursery or greenhouse.



5. Planting.

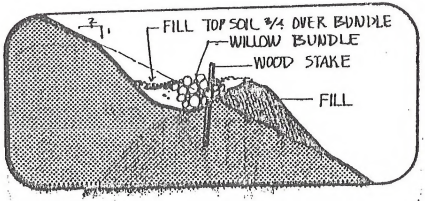
Dormant cuttings: Cuttings may be taken directly from storage to the site for planting. Plant in early spring after the ground has thawed and no later than July 1. To plant the cuttings, stick the shovel into the ground as vertically as possible, push the shovel forward and place the cutting right side up in the ground behind the shovel so that at least three-fourths of the length will be buried. Remove the shovel and step lightly around the cutting to firm the soil. Dormant cuttings should be planted 2-3 feet apart.

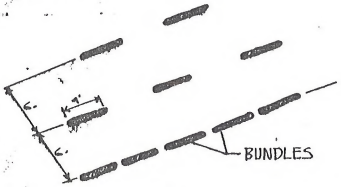




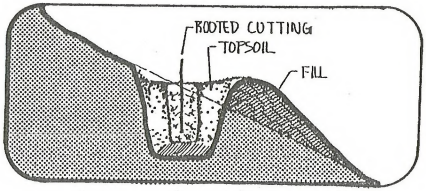
Bundles: A pick or a shovel, 18-inch stakes, and a mallet are necessary for planting bundles. Dig a shallow trench the length of the bundle. The bottom of the trench should slope down and back into the hill. Place the bundle horizontally in the trench. Drive at least two stakes through the bundle to secure it firmly. Drive two additional stakes downhill and immediately in front of the bundle. Cover half of the diameter of the bundle with soil and stamp the soil in place.

Bundles should be planted end to end or slightly overlapping in parallel rows following the contour of the streambank. Bundles should be placed above the ordinary high water line of the stream. The rows of bundles should be spaced 6 feet apart. Rooted or dormant cuttings can be planted in between rows of bundles and the slope may also be seeded lightly with grass.



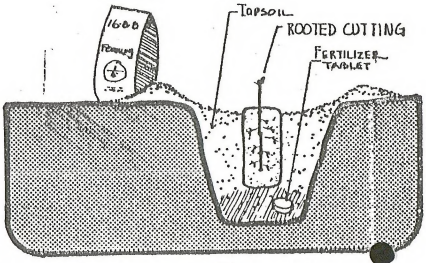


Rooted Cuttings: Before rooted cuttings are planted they should be placed outside for about two weeks during the day and brought inside at night so that they may gradually adapt to the sun, wind, and colder temperatures. The cuttings should not be allowed to freeze. This process is called "hardening off". After the cuttings have been hardened off, they can be taken to the site. Dig a hole deep enough so that the plant can be buried about the same depth that it was in the pot. Remove the cutting from the pot, and loosen any roots that appear to be pot bound. Place the cutting in the hole, backfill with soil and firm into place. Rooted cuttings should be planted 4-6 feet apart.



6. **Planting grass.** Grass may be broadcast seeded over the site, either as a temporary erosion control measure until woody vegetation can be planted or as a permanent cover. However, dense grass cover decreases the success of woody plantings, particularly when dormant cuttings are used. So care must be taken not to plant too much grass. For recommendations on seeding consult *A Revegetation Guide For Alaska* No. 2, A-00146, published by the Rural Development Council in April, 1983, or contact the Alaska Plant Materials Center.

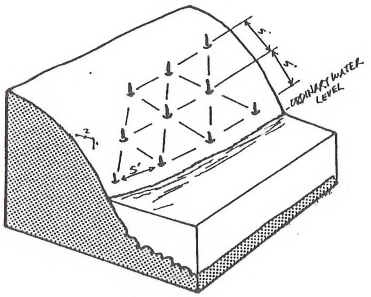
7. **Fertilization.** Fertilization is not necessary but, if desired to speed growth, a slow release, high nitrogen (e.g., 16-8-8, 22-8-2, etc.) fertilizer in tablet , briquette, or spike form can be used. Tablets and briquettes should be placed at the bottom of the hole and covered with a small amount of soil before planting the cutting. Fertilizer spikes are driven into the ground next to the cutting. Two spikes or tablets should be evenly placed along the length of the trench prepared for the bundle. Granular fertilizer, which is applied on the surface, should not be used because it is easily washed into the stream.



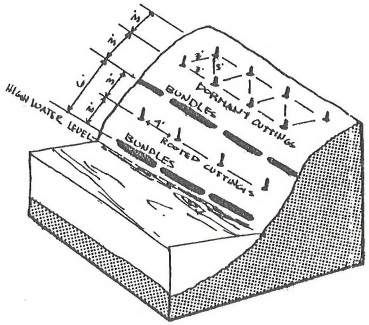
SAMPLE PROBLEM:

A landowner has a streambank that is 100 feet long, 10 feet high above the normal high water line, and with a slope of 2 horizontal to 1 vertical.

Cuttings. The landowner decides to place cuttings every 5 feet on center. If the first row of cuttings are planted at the ordinary water line, three rows of cuttings will be needed. Because the plants are on 5-foot centers the landowner will need 20 plants per row for a total of 60 plants (100 feet long ÷ 5 foot centers = 20 plants per row × 3 rows = 60 plants).



Bundles. The landowner decides to plant bundles end to end with the rows 6-feet apart. The landowner places the lower row at the ordinary high water line and the second row 6-feet higher up the bank. Because each bundle is 4-feet long the landowner will need 25 bundles per row for a total of 50 bundles. (100 feet long ÷ 4 feet per bundle = 25 bundles, 25 bundles per row × 2 rows = 50 bundles). The landowner also decides to plant one row of rooted cuttings 4 feet on center between the two rows of bundles and two rows of dormant cuttings 3 feet on center above the upper bundle row. The landowner will need 25 rooted cuttings and 66 dormant cuttings. (100 feet long ÷ 4 feet on center = 25 rooted cuttings) (100 feet long ÷ 3 feet on center = 33 dormant cuttings per row × 2 rows = 66 dormant cuttings).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SOURCES OF ADDITIONAL INFORMATION

For revegetation information:

Alaska Department of Natural Resources
Plant Materials Center
SRB Box 7440
Palmer, Alaska 99645
Telephone 745-4469

University of Alaska
Cooperative Extension Office
(consult the telephone directory)

U.S. Soil Conservation Service
(consult the telephone directory)

For permit information:

Alaska Department of Fish and Game
Habitat Division
333 Raspberry Road
Anchorage, Alaska 99518-1599
Telephone 267-2284

U.S. Army, Corps of Engineers
Regulatory Branch
P.O. Box 898
Anchorage, Alaska 99506-0898
Telephone 753-2720

For Kenai River permit information:

Alaska Department of Natural Resources
Division of Parks and Outdoor Recreation
Kenai District Office
Box 1247
Soldotna, Alaska 99669
Telephone 262-5581

FIELD NOTES:

VI. GLOSSARY

Abandoned Channel: A channel that was once an active or high-water channel, but currently flows only during infrequent floods.

Active Channel: A channel that contains flowing water during the ice-free season.

Active Floodplain: The portion of a floodplain that is flooded frequently. It contains flowing channels, high-water channels and adjacent bars, but usually contains little or no vegetation.

Adapted Species: Plant species that can complete their entire life cycles and replace themselves in succeeding generations. Introduced and native species can be adapted species.

Adit: A nearly horizontal passage from the surface by which a mine is entered and/or dewatered. An adit may frequently be called a drift or adit level and is sometimes incorrectly referred to as a tunnel but, strictly speaking, a tunnel is open at both ends.

Aesthetics: An enjoyable sensation or a pleasurable state of mind instigated by the stimulus of an outside object. It may be viewed as including action which will achieve the state of mind desired. This concept has a basic psychological element of individual learned response and a basic social element of conditioned social attitudes.

Algae: One or many celled primitive plants that are usually aquatic and capable of rapid growth.

Aliquot: A portion of a disturbed area capable of being worked independently and/or sequentially from other portions of the disturbed area.

Alluvial Fan: A fan-shaped deposit of stream-transported material formed where a stream gradient changes from steep to flat and the water loses most of its carrying power.

Alluvial Stream: A stream which has formed its channel by the process of aggradation where the sediment it carries (except for the wash load) is similar to that in the bed.

Alluvium: Detrital deposits resulting from the operations of modern rivers and streams. Includes sediments laid down in river beds, floodplains, lakes, fans at the foot of mountain slopes, and deltas.

Anadromous: Aquatic organism migrating from marine waters to freshwater for reproduction.

Angle of Repose: The maximum slope or angle at which a material such as soil or loose rock remains gravitationally stable.

Aquifer: A permeable strata or zone below the ground surface through which ground water moves in sufficient quantities to provide water for wells or springs.

Arctic: The north polar region bounded on the south by the Arctic Circle.

Armor Layer: A layer of sediment that is coarse relative to the material it covers and that is erosion resistant to frequently occurring floods. It may form naturally by the erosion of finer sediment, leaving coarser sediment in place or it may be placed by man to prevent erosion.

Artesian Water: Ground water under sufficient pressure to rise above the level at which it is encountered by a well.

Aufeis: An ice feature formed by water overflowing onto a surface, such as river ice or gravel deposits, and freezing with subsequent layers of ice buildup formed by more water overflowing onto the ice surface itself and freezing. A frequent source of the water is shallow groundwater flow forced to the surface by a constriction in the flow area. This ice feature may also be described as icings, glaciation and/or naleds.

Authorized Officer (AO): Any employee of the Bureau of Land Management to whom authority has been delegated to perform certain defined duties.

Backfill and grade: To place soil, overburden, or waste rock into a surface excavation, and level or shape this fill material to a desired surface configuration.

Backwater Analysis: A hydraulic analysis which computes a water surface profile in a reach of channel with varying bed slope and/or cross-sectional shape.

Backslope: Final cut face or slope on an embankment or cut.

Bank: A comparatively steep side of a channel or floodplain formed by an erosional process. Its top is often vegetated.

Bank-Full Discharge: Water discharge corresponding to the stage at which the overflow plain begins to be flooded.

Bank-Full Stage: The maximum flow which a given channel is capable of passing without overtopping its banks.

Bar: An alluvial deposit or bank of sand, gravel or other material at the mouth or other point in the stream flow.

BAT: Best Available Technology, economically achievable.

Beach Terrace: Remnants of former beaches elevated well above present high water level.

Beaded Stream: A small stream, located in areas underlain by permafrost, containing a series of deep pools interconnected by very small channels.

Bed: The bottom of a watercourse.

Bed Load: Sand, silt, gravel or soil and rock detritus carried by a stream on, or immediately above, its bed.

Bed Load Material: The portion of the sediment load of a stream which is composed of particle sizes found mainly in the shifting portions of the bed.

Bed, Movable: A stream bed made up of materials readily transportable by the stream flow.

Bed, Stream: The bottom of a stream below the low summer flow.

Bedrock Drain: A bedrock drain is a trench up a creek at a flatter gradient than the creek, which reaches bedrock at its upper drain.

Bench: A relatively flat area occurring along valley walls. A level layer worked separately in a mine.

BMP: Best Management Practice.

Boreal: A northern forest, typical of interior Alaska, comprised of birch, poplars, white and black spruce and cottonwood.

Braided Stream: A braided stream is one flowing in several dividing and reuniting channels resembling the strands of a braid. A stream containing two or more interconnecting channels separated by unvegetated gravel bars, sparsely vegetated islands or occasionally heavily vegetated islands. Its floodplain is typically wide and sparsely vegetated and contains numerous high-water channels. The lateral stability of this system is quite low within the boundaries of the active floodplain.

Break-Up: The spring thaw when the ice breaks up on the rivers.

Broadcast Seeding: Randomly scattering seed on the ground's surface. Aerial seeding and hydroseeding are types of broadcast seeding.

Cache: A storage place for provisions and supplies.

Cadastral: Delineating and recording property boundaries.

Carrying Capacity, Biological: The maximum number of a given organism that can be maintain indefinitely by a habitat.

Carrying Capacity, Discharge: The maximum rate of flow that a channel is capable of passing.

Casual Use: Activities ordinarily resulting in only negligible disturbance of the lands and resources.

Channel: A natural or artificial waterway of perceptible extent which periodically or continuously contains moving water. It has a definite bed and banks which serve to confine the water.

Channel Capacity: The maximum flow which a given channel is capable of transmitting without overtopping its banks. Also described as bank full stage.

Clay: The term clay as used today carries with it three implications: a natural material with plastic properties, an essential composition of particles of very fine size grades, and an essential composition of crystalline fragments of minerals that are essentially hydrous aluminum silicates or occasionally hydrous magnesium silicates. The term implies nothing regarding origin but is based on properties, texture, and composition, which are, of course, interrelated-e.g., the plastic properties are the result of the constituent minerals and their small grain size.

Cleanup: To recover gold or other valuable minerals from sluices, plates, tables or other collection devices.

Climax Species: Species that dominate an ecosystem, usually at a mature stage of ecological succession.

Compaction: The packing of loose surface materials into a hard, dense surface.

Companion Crop: An annual seed, such as annual rye, that is broadcast to modify microenvironmental conditions before or during initial establishment efforts.

Competition: Two or more species in the same ecosystem attempting to use the same scarce resources.

Configuration: The pattern of a channel as it would appear by looking down at the channel from above.

Contour: A line of equal elevation relative to a specific datum.

Cover, Bank: Areas associated with or adjacent to a stream or river that provide an animal with resting shelter and protection from predators (e.g. undercut banks, overhanging vegetation, accumulated debris, etc.).

Cover Crop: An annual seed, such as annual rye, that is broadcast to modify microenvironmental conditions before or during initial establishment efforts.

Cover, Fish: Areas of shelter in a stream channel that provide fish protection from predators and/or a place to rest and conserve energy due to a reduction in the force of the current (e.g. pools, boulders, water depths, surface turbulence, undercut banks, overhanging vegetation, accumulated debris, etc.).

Critical Slope: see Angle of Repose.

Cross-Section Area: The area of a stream, channel or waterway opening, usually measured perpendicular to the stream centerline.

Current: The flowing of water or other fluid. That portion of a stream of water which is moving with a velocity much greater than the average or in which progress of the water is principally concentrated (not to be confused with a unit of measure -- see velocity).

Cut: An excavation open to the air.

Cutbank: The concave wall of a meandering stream that is maintained as a steep or even overhanging cliff by the impinging of water at its base.

Datum (Data): Any numerical or geometrical quantity or set of such quantities which may serve as a reference or base for other quantities. An agreed standard point or plane of stated elevation, noted by permanent bench marks on some solid immovable structure from which elevations are measured or to which they are referred.

DBH: Diameter of a tree at Breast Height.

Detention Time: Period of time that water remains in a settling pond. It equals the flow rate divided by the volume of the pond. Also "Retention Time".

Dewater: the draining or removal of water from an enclosure, channel, or material.

Discharge: The rate of flow or volume of water flowing in a given stream at a given place and within a given period of time. Usually expressed as cfs (Cubic Feet per Second).

Diversity: Physical or biological complexity of a system, which in many cases leads to ecosystem stability.

Dragline: A type of excavating equipment that uses a bucket and a boom, in conjunction with cables. It is capable of the removal of underwater material.

Dike: A wall built partially or totally around an area to prevent fluids from entering or leaving the area.

Dip: The angle or inclination at which a bed, vein or stratum is inclined from the horizontal.

Drainage Area: The entire area drained by a river or system of connecting streams such that all stream flow originating in the area is discharged through a single outlet.

Dredge: Any method of removing material from active channels. Also, a combined floating excavating machine and concentration system used in placer mining or other excavating activities.

Drift: A horizontal passage underground which follows a vein; as distinguished from a crosscut, which intersects it, or a level or gallery, which may do either. In coal mining, a drift is an above water level gangway or entry driven from the surface in the seam.

Drift, Glacial: Any rock material, such as boulders, till, gravel, sand or clay transported by a glacier and deposited by or from the ice.

Drift, Invertebrate: The aquatic or terrestrial invertebrates which have been released from (behavioral drift) or have been swept from (catastrophic drift) the substrate or have fallen into the stream and move or float with the current.

Duration Curve: A mathematical curve with all the units of an item, such as head and flow, arranged in order of magnitude along the ordinate, and time, frequently expressed in percentage, along the abscissa, to give a graphical representation of the number of times given quantities are equaled or exceeded during a certain period of record.

Ecology: The study of the relationships between organisms and their environments.

Ecological Succession: Change in the structure and function of an ecosystem; replacement of one type of community or organism with a different community over a period of time (see primary succession, secondary succession).

Ecosystem: Self-sustaining and self-regulating community of organisms interacting with one another and with their environment.

Environment: Aggregate of external conditions that influence the life of an individual organism or population.

Ephemeral Stream: A stream or portion of a stream which flows only in direct response to precipitation. It receives little or no water from springs and no long-continued supply from melting snow or other sources. Its channel is above the water table.

Erosion: 1. The physical process of sediment removal by wind or water. 2. The wearing away of the land surface by running water, wind, ice, or other geological agents, including such processes as gravitational creep; the detachment and movement of soil or rock fragments by water, wind, ice, or gravity.

Erosion, Stream Bed: The scouring of material from the water channel and the cutting of the banks by running water. The cutting of the banks is also known as stream bank erosion.

Escarpment: A steep face terminating high lands abruptly, as contrasted with the backslope, the less-sloping side of a ridge.

Exotic Species: Not native to the place where found.

Face: End of surface where work is being or was last done in any level or gently inclined part of an excavating operation.

Federal Lands: Lands subject to the mining laws including, but not limited to, the certain "public lands" defined in section 103 of the Federal Land Policy and Management Act of 1976.

Fines: The finer grain size particles of a mass of soil, or sediment. The material, in hydraulic sluicing, that settles last to the bottom of a mass of water (except when flocculated).

Float: Ore or rock which has been separated from the in-place parent material by weathering and erosion.

Flocculant: A substance that induces or promotes flocculation.

Flocculate: To aggregate into small lumps; said especially of soils and colloids.

Flood: Any flow which exceeds the bankfull capacity of a stream or channel and flows out on the floodplain (i.e. greater than bankfull discharge).

Floodplain: The relatively level land composed of primarily unconsolidated river deposits that is located adjacent to a river and is subject to flooding. It contains an active floodplain and sometimes contains an inactive floodplain and/or terrace(s).

Flow: The movement of a stream of water and/or other mobile substances from place to place; or the total quantity carried by a stream (i.e. discharge).

Flow, Base: The base flow is the portion of the stream discharge derived from natural storage. Base flow originates from sources such as groundwater outflow, the draining of large lakes and/or swamps or any other source which is outside the net rainfall and surface runoff. Base flow, sometimes called sustaining flow, can also be viewed as the discharge sustained in a stream channel which is not a result of direct runoff and has not been affected by man-made regulation or diversion.

Flow, Low: The lowest discharge recorded over a specified period of time.

Flow, Low Summer: The lowest flow during a typical open-water season.

Flow, Mean: The average discharge at a given stream location computed for the period of record by dividing the total volume of flow by the number of days, months or years in the specified period.

Flow, Uniform: A flow in which the velocities are the same in both magnitude and direction from point to point. Uniform flow is possible only in a channel of constant cross section.

Flow, Varied: Flow occurring in streams having a variable cross section or slope. When the discharge is constant, the velocity changes with each change of cross section and slope.

Fluvial: Of, or pertaining to, rivers; growing or living in streams or ponds produced by river action, as a fluvial plain.

Fork Length: The length of a fish measured from the tip of the nose to the fork in the tail.

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Freeboard: The vertical distance from the top of the channel to the water surface at the design condition.

Freeze Front: A mobile or stationary two-sided surface with one surface having a temperature of 0°C and the other surface being either warmer or colder.

French Drain: A trench loosely backfilled with stones, with the largest stones at the bottom and the size decreasing toward the top. The spaces between the stones serve as a passageway for water.

Frequency Curve: A curve of the frequency of occurrence of specific events. The event that occurs most frequently is termed the mode.

Gabion: A large cage filled with earth, gravel or rocks used to stabilize embankments.

Gage: A device for indicating or registering magnitude or position in specific units (e.g. the elevation of a water surface or the velocity of flowing water). A staff graduated to indicate the elevation of a water surface.

Geology: The science that deals with the physical nature of the earth, including: its structure and crustal development, the composition and structure of its interior, its history, past life forms and rock and mineral types.

Geomorphology: The study of the form and development of landscape features.

Grizzlies: Iron or steel bars used to sort or separate large rocks from finer grained materials.

Groin: A shore-protection and improvement structure usually built to trap littoral drift or retard erosion of the shore. It is narrow in width and extends from a point landward of the shoreline out into the water.

Habitat: The place where a population of animals live, including the living and nonliving surroundings. The area in which an animal is provided with its life requirements such as food and shelter.

Hardpan: Layers of gravel occurring a few feet below the surface and cemented by limonite. A hard, impervious layer, composed chiefly of clay, cemented by relatively insoluble materials; it does not become plastic when mixed with water, and definitely limits the downward movement of water and roots.

Haulageway: The gangway, entry or tunnel through which broken rock or materials and supplies are transported.

High Grade: Rich ore.

Highwall: 1. The unexcavated face of exposed overburden and bedrock in a surface mine; 2. The face or bank on the uphill side of a contour mine.

High-Water Channel: A channel that is dry most of the ice-free season but contains flowing water during floods.

Hopper: A vessel into which materials are fed, usually constructed in the form of a cone or inverted pyramid, terminating in an opening through which the materials are discharged.

Hydraulics: The science dealing with water or other fluids in motion. Stream hydraulics deals with the mechanics of the conveyance of water in a watercourse.

Hydraulic depth: The average depth of water in a stream channel. It is equal to the cross-sectional area divided by the linear surface width.

Hydraulic Geometry: Measures of channel configuration, including depth, width, slope.

Hydraulic Mining: A method of mining in which an ore bearing soil, sediment, or rock is washed away by a powerful jet of water and carried into sluices where the ore is separated from the other materials by its specific gravity.

Hydraulic Radius: The cross-sectional area of a stream of water divided by the length of that part of its periphery in contact with its containing channel (i.e. the ratio of area to wetted perimeter).

Hydraulicing: An operation which uses water at high pressures to move earth materials downslope. It can be used in thawing frozen soils.

Hydrograph: A graph showing, for a given point on a stream, the discharge, stage, velocity or other property of water with respect to time.

Hydrology: The study of the origin, distribution and properties of water on or near the surface of the earth.

Hydroseeding: Spraying seed on the site with a stream of water.

Ice-Rich Material: Permafrost material with a high water content in the form of ice. The body of ice often takes the shape of a vertical wedge or a horizontal lens.

Ice Wedge: A large mass of ice, often wedge-shaped, extending vertically downward in permafrost.

Impermeable: Not permitting water to pass through under the head differences ordinarily found in ground water. Applied to materials such as clays and shales. A relative term.

Impervious: A term applied to a material through which water cannot pass or through which water passes with great difficulty.

Inactive Floodplain: The portion of a floodplain that lies between the riparian zone and 100-year recurrence interval flood boundary.

Inlet: An opening for intake in a pipe, culvert, pond, etc..

Intermittent Stream: Stream which flows only part of the year when it receives flow from springs, surface sources such as melting snow or wet, rainy weather.

Island: A sediment deposit, or other emergent land feature located between two channels, or otherwise surrounded by surface water.

Lateral Accretion: Wherever a stream meanders, it erodes its outer bank, while the other bank is building up (accreting) by the deposition of material brought there by the stream.

Lateral Bar: An unvegetated or lightly vegetated sediment deposit located along the side of a channel, not associated with a meander. Transient in character. Due to local variation in sediment transportaion and deposition (i.e., stream energy).

Lateral Erosion: The action of the stream in impinging on one side of its channel and undermining the bank, so that masses of material fall into the stream. The channel shifts toward the bank which is being undercut.

Leach: To wash or drain by percolation. To dissolve minerals or metals out of the ore, as by the use of cyanide or chlorine solutions, acids, or water.

Leaching: 1. The removal of soluble salts or metals from the accompanying materials by the use of a suitable solvent. 2. Process of decomposition of rocks under natural agencies. Surface waters penetrating downward may dissolve some or all of the mineral and other materials in their path, thus carrying such dissolved materials away from the surface zone.

Limonite: A mixture of iron oxides and hydroxides. Amorphous yellow or reddish-brown to black in color. Limonite is formed by the weathering of minerals that contain iron.

Lode: A lode, vein or ledge is a deposit of valuable mineral which has relatively definite boundaries. A lode is not a placer. It consists of quartz or other minerals/rock in place, and contains valuable minerals.

Loess: A deposit of silty material having an open structure and relatively high cohesion due to cementation by clay or calcareous material at the grain contacts. A characteristic of loess deposits is that they can stand with nearly vertical slopes. Generally a wind-derived ("aeolian") deposit.

Manning's Equation: In current usage, an empirical formula for the calculation of discharge in a channel.

Mean Column Velocity: The water velocity measured at 0.6 of the depth or the average of the velocities as measured at 0.2 and 0.8 of the depth.

Mean Flow: The average discharge at a given stream location computed for the period of record by dividing the total volume of flow by the number of days, months or years in the specified period.

Mean Water Velocity: The average velocity of water in a stream channel which is equal to the discharge in cubic feet per second divided by the cross-sectional area in square feet.

Meander: One of a series of somewhat regular and looplike bends in the course of a stream.

Meander Wave Length: The average downvalley distance of two meanders.

Meandering Stream: A stream winding back and forth within the floodplain. The meandering channel shifts downvalley by a regular pattern of erosion and deposition. Few islands are found in this type of river and gravel deposits typically are found on the point bars at the insides of meanders.

Microhabitat: Specific local areas within a community or habitat type that are utilized by organisms for specific purposes and/or events in their life cycles. The presence of specific types of habitat and cover (microhabitats) can allow an organism to make more effective use of larger areas to maximize their productive capacity.

Mid-Channel Bar: An unvegetated or lightly vegetated sediment deposit located between two channels. Transient in character.

Mitigation: The Council on Environmental Quality's definition of mitigation: "(a) avoiding the impact altogether by not taking a certain action or parts of an action; (b) minimizing impacts by limiting the degree or magnitude of the action and its implementation; (c) rectifying the impact by repairing, rehabilitating, or restoring the affected environment; (d) reducing or eliminating the impact over time by preservation and maintenance operations during the life of the action; and (e) compensating for the impact by replacing or providing substitute resources or environments (40 CFR, Part 1508.20 [a-e]).

Mountain Stream: A single channel, high gradient stream.

Mulch: Any nonliving material placed or left on or near the soil surface for the purpose of protecting it from erosion or protecting plants from heat, cold or drought.

Native Species: Living or growing naturally in a given region; indigenous.

Nonpoint-Source Pollution: All pollution, such as turbidity, suspended sediment and sedimentation resulting from soil erosion, caused by human activity and emanating from a widespread area.

Nurse Crop: A crop planted with another presumably to shelter it from competition with weeds or other undesirable plants.

Operation: 1. Performance of a practical work or of something involving the practical application of principles or practice. 2. The quality or state of being functional or operative; a method or manner of functioning. 3. All functions, work, facilities, and activities in connection with prospecting, discovery and assessment work, development, extraction, and processing of mineral deposits locatable under the mining laws and all other uses reasonable incident thereto, whether on a mining claim or not, including but not limited to the construction of roads, transmission lines, pipelines, and other means of access for support facilities across Federal lands subject to these regulations.

Operator: A person conducting or proposing to conduct an operation.

Ore: An aggregate of minerals that can be extracted at a profit.

Original Contour: The pre-mining surface configuration of the land, not necessarily the pre-mining elevation.

Outlet: A means of exit from a pipe, culvert, pond, etc..

Overburden: 1. Any organic or inorganic material lying on top of placer gravels. 2. Material that overlies a deposit of useful materials or ores, especially those deposits mined from the surface by open cuts.

Overflow Rate: Rate of flow through a settling pond divided by the surface area of the settling pond.

Parameter: A variable in a mathematical function which, for each of its particular values, defines other variables in the function.

Paystreak: A limited horizon within a placer deposit, containing a concentration of values or made up of material rich enough to mine.

Perennial Stream: Streams that flow throughout the year from source to mouth.

Permafrost: Perennially frozen ground.

Permeability: 1. The quality of a soil horizon that enables water or air to move through it. 2. The property or capacity of a porous rock sediment or soil for transmitting a fluid without impairment of the structure of the medium; a measure of the relative ease of fluid flow under unequal pressure.

Physiography: The study of the genesis and evolution of land forms.

Pingo: Relatively large mound raised by frost action above the permafrost and generally persisting for more than a single reason.

Pit: 1. Topog: A cavity or hole in the ground, natural or artificial. 2. An open excavation made to obtain material of value.

Placer: A place where gold is obtained by washing; an alluvial or glacial deposit, as of sand or gravel, containing particles of gold or other valuable mineral. In the United States mining law, mineral deposits, not veins in place, are treated as placers, so far as locating, holding, and patenting are concerned. Various minerals besides metallic ores have been held to fall under this provision, but not coal, oil, or salt.

Placer, Beach: Placer deposits either on a present or ancient sea beach such as Nome, Alaska.

Placer, Bench: Placers in ancient stream deposits, now situated at elevations above the present streams. Placer in a part of a valley not occupied by the present active channel.

Placer, Buried: Ancient placer deposits which have become buried beneath lava flows or other younger deposits of sediments.

Placer, Deposit: A mass of gravel, sand or similar material resulting from the weathering and erosion of solid rocks, and containing valuable minerals (e.g. gold, tin, diamonds, platinum-group elements, etc.).

Placer, Eluvial: A placer deposit on a hillside, transitional between residual and stream placers.

Placer, Hillside: Placer on the slope of a hill. Eluvial placer.

Placer, Lake-bed: Placers accumulated in the beds of present or ancient lakes.

Placer Mining: That form of mining in which surficial detritus is processed for the recovery of gold or other valuable minerals. When water under pressure is employed to break down the gravel, the term hydraulic mining is generally employed. There are deposits of detrital material containing gold which lie too deep to be profitably extracted by surface mining, and which must be worked by drifting beneath the overlying barren material. To the operations necessary to extract such auriferous material the term drift mining is applied.

Plastic: Capable of being molded into any form, which is retained.

Point Bar: An unvegetated sediment deposit located adjacent to the inside edge of a channel in a meander bend. Transient in character.

Point-Source Pollution: Pollution which originates at a single entry point into a body of water.

Pool: A body of water or portion of a stream that is deep and quiet relative to the main current.

Pool, Plunge: A pool, basin or hole scoured out by falling water at the base of a waterfall.

Pore: 1. Interstice; void, q.v. A space in rock or soil not occupied by solid mineral matter.

Porosity: The percentage of void space in earth material such as soil, sediment, or rock.

Porous: Containing voids, pores, interstices, or other openings which may or may not interconnect.

Profile: In open channel hydraulics, it is the water or bed surface elevation graphed against channel distance.

Project Area: A single tract of land upon which an operator is, or will be, conducting operations.

Public Lands: See "Federal Lands".

Propagula: A propagable portion of a plant, capable of reproduction of the species.

Raise or Rise: A mine shaft driven upward from below.

Reach: A comparatively short length of a stream, channel or shore.

Reclaim: 1. to claim or demand the return or restoration of, as a right, possession, etc. 2. to claim again. 3. to bring (wild, waste, or marshy land) into a condition for cultivation or other use. 4. to recover (substances) in a pure or usable form from refuse, discarded articles, etc. 5. to bring back to a preferrable manner of living, sound principles, ideas, etc. 6. to tame.

Reclamation: 1. the reclaiming of waste, desert, marshy, or submerged land for cultivation or other use. 2. the act or process of reclaiming. 3. the state of being reclaimed. 4. the process of industry of deriving usable materials from waste, byproducts, etc.

Regional Hydraulic Analysis: Estimating the hydraulic parameters of one river by using the measured values of the same parameters at other rivers within a selected region.

Rehabilitate: 1. to restore to a condition of good health, ability to work, or the like. 2. to restore to good operation or management, as a bankrupt business. 3. to reestablish the good reputation of (a person, one's character or name, etc.). 4. to restore formally to former capacity, standing, rank, rights, or privileges.

Resident Fish: Remaining in freshwater for entire life cycle.

Restoration: 1. the act of restoring, renewal, revival, or reestablishment. 2. the state or fact of being restored. 3. a return of something to a former, original, normal, or unimpaired condition. 4. restitution of something taken away or lost. 5. something which is restored. 6. a representation or reconstruction of an ancient building, extinct animal, or the like, showing it in its original state. 7. a putting back into a former position, dignity, etc.

Restore: 1. to bring back into existence, use, or the like; reestablish; to restore order. 2. to bring back to a former, original or normal condition, as a building, statue, or painting, 3. to bring back to a state of health, soundness, or vigor. 4. to put back to a former place, or to a former position, rank, etc. 5. to give back; make return or restitution of (anything taken away or lost). 6. to reproduce, reconstruct, or represent (an ancient building, extinct animal, etc.) in the original state.

Retention Time: See "Detention Time".

Riffle: A shallow rapids in an open stream where the water surface is broken into waves by obstructions wholly or partly submerged; also the slats, angle iron, etc. placed across the bottom of a sluice box in placer mining.

Riparian: Pertaining to anything connected with or adjacent to the banks of a stream or other body of water.

Riparian Vegetation: Vegetation bordering floodplains and occurring within the active floodplain.

Riparian Zone: Area within the active floodplain adjacent to active stream channels.

Riprap: Large sediments or angular rock used as an artificial armor layer.

River Regime: A state of equilibrium attained by a river in response to the average water and sediment loads it receives.

Root Stock: Any root or lower stem mass from woody shrubs and small trees.

Run: A stretch of relatively deep, fast flowing water where the surface is essentially nonturbulent.

Runoff: A portion of precipitation that appears in surface streams. It is the same as streamflow unaffected by artificial diversions, storage, or other works of man, in or on the stream.

Scour: The removal of sediments by running water. Scour is usually associated with removal of sediments from the channel bed or floodplain surface.

Scrape: A method of removing floodplain gravels or other materials from surface deposits using tractors or scrapers.

Screen: A device used to separate particulate material into size classifications.

Sediment Discharge: The volumetric rate of sediment transfer past a specific river cross section.

Settling Ponds: Artificial structures designed to prevent downstream pollution by trapping and removing sediment from waters draining a surface disturbing operation.

Shaft: A vertical or incline excavation through which a mine is worked.

Sinuous River: Sinuous channels are similar to meandering channels with a less pronounced winding pattern. The channel may contain smaller point bars and have less tendency for downvalley shifting. The channels are more stable with respect to lateral shifting.

Sinuosity: A measure of the amount of winding of a river within its floodplain expressed as a ratio of the river channel length to the corresponding valley length.

Slope: The inclination or gradient from the horizontal of a line or surface.

Sluice Box: Box with riffles through which gravel is washed to recover gold or other valuable materials.

Sluicing: A general term applied to many forms of placer mining. A sluice is an inclined channel or trough through which gravel is carried by a stream of water with the intent to separate gold or other valuable materials of relatively high specific gravity.

Soil: The material produced by the effects of weathering and the action of plants and animals on the rocks and minerals at the surface of the Earth.

Solid Waste: Solid, liquid, semi-soluble or contained gaseous material which is discarded, has served its intended purpose, or is a manufacturing or mining by-product. Excluded from this regulation under the Resource Conservation and Recovery Act of 1976 (RCRA) are the following: domestic sewage; Clean Water Act point source discharge; irrigation return flow; AEC source, special nuclear, or by-product material; in-situ mining waste. (40 CFR 260, App. 1)

Specific Gravity: Ratio of the mass of a body to the mass of an equal volume of water at a specified temperature.

Split River: A river having numerous islands dividing the flow into two channels. These islands and banks are usually heavily vegetated and relatively stable. The channels tend to be narrower and deeper and the floodplain narrower than for a braided system.

Spoil: 1. Debris or waste material from a mine. 2. Overburden or mineral waste excavated and redeposited in surface mining.

Spoil Ridge: A series of contiguous piles of spoil deposited adjacent and roughly parallel to the mine excavation.

Spoil Peak: The highest point of an individual spoil pile.

Stage: The elevation of a water surface above or below an established datum or reference.

Stope: An underground excavation from which ore has been extracted from either above (overhand) a level or below (underhand) a level in a series of steps.

Straight River: The thalweg of a straight river typically winds back and forth within the channel. Gravel bars tend to form opposite where the thalweg approaches the side of the channel. These gravel bars may not be exposed during low flow. Banks of straight systems typically are relatively stable and floodplains are usually narrow. These river systems are considered to be an unusual configuration in transition to some other configuration.

Strike: The compass bearing or direction of the outcrop of an inclined bed, vein or structure on a level surface.

Subarctic: The boreal forest region.

Subsoil: A layer of the regolith, grading into the soil above and into unmodified rock waste below, which is less oxidized and hydrated than the soil proper and contains almost no organic matter, but is somewhat charged with and indurated by iron oxides and clay that has been leached down from the overlying soil.

Substrate: Stream bottom materials including silts, sands, gravels, cobbles, boulders and bedrock.

Sump: A hole or pit which serves for the collection of mine waters.

Survival Standards: Standards to measure the effectiveness of the revegetation phase of reclamation by the extent to which seeded or planted species become capable of self-regenerative growth (usually measured by percent of area having specific types of growing plants and the sizes of plant-devoid areas).

Suspended Sediment: The portion of stream load moving in suspension. Particles of such density or grain size as to permit suspended, long distance movement out of contact with the stream bed. Small particles held in suspension in the water column by collodial effects and/or the upward components of turbulent currents.

Tailing Piles: Material which has been processed through a mining operation and stacked in piles.

Talik: A zone of unfrozen material within an area of permafrost.

Terrace: An elevated abandoned floodplain formed as a result of stream degradation. It is expected to be inundated further only by infrequent flood events.

Thalweg: The line following the lowest part of a valley whether under water of not. It is usually the line following the deepest part or middle of the bed or channel of a river or stream.

Thermokarst: Landforms that appear as depressions in the ground surface or cavities beneath the ground surface which result from the thaw of ice-rich permafrost material.

Topsoil: The original or present dark-colored upper soil that ranges from a mere fraction of an inch to 2 or 3 feet thick on different kinds of soil. Most soil organic matter is concentrated in topsoil.

Top Width: The width of the effective portion of flow across a stream channel.

Toxic Material: Any substance present in sufficient concentration or amount to injure plant or animal life.

Trommel: A revolving cylindrical screen used in size-grading coarsely crushed material. The material to be screened is delivered inside the trommel at one end, the finer material drops through the holes and the coarser is delivered to the other end.

Turbidity: An expression of the optical property that causes light to be scattered and absorbed rather than transmitted in straight lines through a water sample. Turbidity in water is caused by the presence of suspended matter such as clay, silt, finely divided organic and inorganic matter, plankton and other microscopic organisms.

Universal Soil Loss Equation: An equation used for the design of water erosion control systems. A = RKLSPC where A = average annual soil loss in tons per acre per year; R = rainfall factor; K = soil erodability factor; L = length of slope; S = percent of slope; P = conservation practice factor and C = cropping and management factor. Frequently difficult to apply in a rigorously meaningful manner in many instances, due to lack of valid appropriate values for various factors.

Unnecessary or Undue Degradation: Surface disturbance greater than what would normally result when an activity is being accomplished by a prudent operator in usual, customary, and proficient operations of similar character and taking into consideration the effects of operations on other resources and land uses, including those resources and uses outside the area of operations. Failure to initiate and complete reasonable mitigation measures; including reclamation of disturbed area or creation of a nuisance may constitute unnecessary or undue degradation. Failure to comply with applicable environmental protection statutes and regulations thereunder will constitute unnecessary or undue degradation. Where specific statutory authority requires the attainment of a stated level of protection or reclamation, such as in the California Desert Conservation Area, Wild and Scenic Rivers, areas designated as part of the National Wilderness System administered by the Bureau of Land Management and other such areas, that level of protection shall be met.

Velocity: The time rate of motion. The distance traveled divided by the time required to travel that distance.

Wash Load: In a stream system, the wash load is the relatively fine material in near permanent suspension which is transported entirely through the system without being deposited.

Water Quality: A term used to describe the chemical, physical and biological characteristics of water in reference to its suitability for a particular use.

Wetted Perimeter: The length of the wetted contact between the stream of flowing water and its containing channel measured in a plane at right angles to the direction of flow.

Wildlife: All living things that are neither human nor domesticated. The definition is most often restricted to animal wildlife species other than fish and invertebrates. Generally does not include plants.

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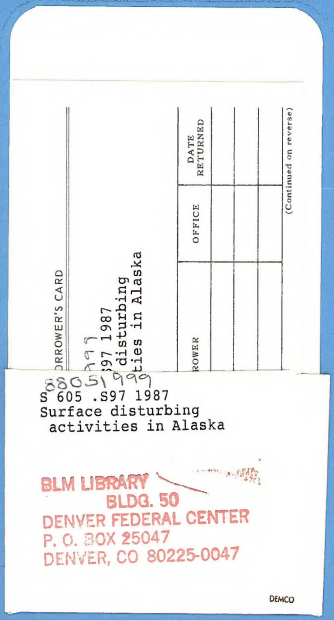
IX. CASE HISTORIES

Note: Case histories will be added as they are developed (1987 - ...) and become available.



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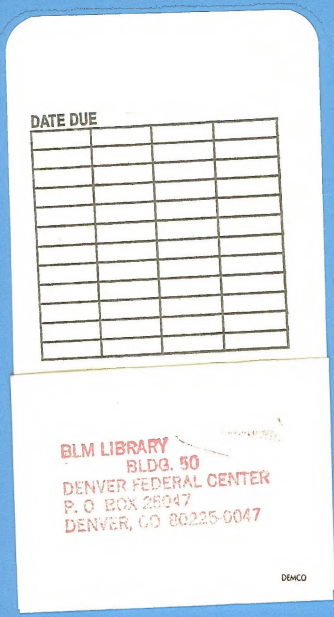
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